BEGINNERS

RTTY HANDBOOK

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THIS BOOK IS DEDICATED TO THE AUTHORS SUPPLYING MATERIAL TO THE RTTY JOURNAL THROUGH THE YEARS. SPECIAL THANKS TO Ron, W8BBB and Irv W6FCC. To Paul KOPJ/6 SPECIAL THANKS FOR CORRECTING THE MANY ERRORS WE MADE AND TO John, KA6NYK FOR GIVING ME THE SUPPORT IT TOOK IT GET IT ACCOMPLISHED AND PUTTING UP WITH ME. 73 and 88.

DEE CRUMPTON-GOHEEN, N6ELP
PUBLISHER RTTY JOURNAL

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RTTY FOR THE BEGINNER

The purpose of this handbook is to acquaint someone new to RTTY (Radio TeleType) with the fundamentals of teleprinter operation and the application of teleprinters to transmission and reception by means of radio.

The material is divided into four general categories:
1) Teleprinters, 2) Receiving, 3) Transmitting, and 4) "Advanced" General Topics.

The approach is to begin with the assumption that the reader has zero knowledge about teleprinters and slowly build to the point where it is possible to connect a teleprinter to "talk to itself"; probably the most difficult step for a beginner is getting a teleprinter operating on a local loop (actually, it is quite easy to do , but, conceptually, it is a big step). The biggest mistake made by a beginner is to try to do too much at once without an understanding of the individual components and their functions.

Once the machine is properly operating in a local loop "talking to itself" as it were - it is then permissible to move to receiving signals "off the air": this is a relatively easy step. The final step is transmitting; this last step can be either very easy or quite difficult depending on the mode of transmission desired - FSK or AFSK- and the specific method of implementation.

Whenever possible, the "why" is explained before the "how". Understanding why something is done a particular way always helps one to understand how to do it (and how to do it better). Sometimes things are done in what appears to be a completely illogical manner (such as having loop current flowing when "nothing" is being transmitted); such "illogical" procedures generally have an historical (seemingly hysterical?) reason once the historical perspective is gained, the "illogical" becomes superbly logical.

THE TELEGRAPH

It will be an aid to understanding why present day Teletype equipment works the way it does if some pertinent historical facts are discussed.

The telegraph was invented and in widespread use before the Teletype. The biggest problems with the telegraph are/were the relatively slow speed of operation and the necessity for highly trained operators at each end. The Teletype was invented for the purposes of increasing the speed of operation and using operators with less skill. Because the telegraph was in widespread use when the Teletype came along, much of the then existing terminology and circuit features were incorporated into the Teletype. In fact, the term "Teletype" is a relatively new term and is copyrighted. The most commonly used term for Teletype was "printing telegraph", and it is still common to refer to Teletype equipment and circuits as "telegraph" equipment and circuits. The circuits used for wiring telegraph and Teletype differ only in the equipment used at the ends.

If we examine a simple telegraph circuit and the "code" used with a hand keyed telegraph circuit, certain similarites and some gross differences between hand keyed and printing telegraphy will become apparent.

A SIMPLE TELEGRAPH CIRCUIT

Figure 1 shows a simple hand keyed telegraph circuit. Whenever the key at the sending end is depressed, current flows over the loop or line,thru the sounder, and back to the sending end thru the Earth. The sounder is a simple devise having the appearance of a relay without contacts. Whenever current flows in the sounder magnets, the armature on the sounder is attracted by the magnets, and as the armature strikes the stop it makes a click or a "sound".

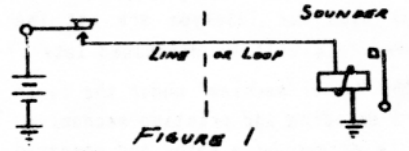

FIGURE 1

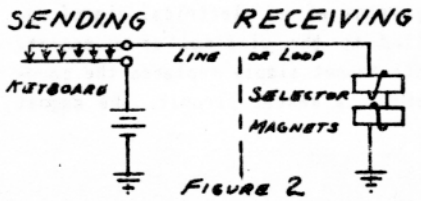

FIGURE 2

(The code used on wire-line telegraphy, the Morse code, and the code used by radio amateurs for CW operations are not the same code, although they are similar. The wire-line Morse code uses clicks of the receiving sounder while the radio code uses bursts of tone.)

One of the objections to telegraphy as just described is the necessity for an operator to be present at the receiving end to listen to the sounder and write down what was sent as it was being sent. One solution to this problem was to have some type of device at the receiving end to make marks on a moving strip of paper in order to automatically receive a message when no receiving operator was present. The "automatic recorder" consisted of a simple arrangement containing a pen fastened to the armature of a modified sounder. Whenever the key at the sending end was depressed, the armature on the "modified" sounder would move placing the pen in contact with the moving paper and a mark was made upon the paper. When the sending key was opened, no current flowed, the armature on the "sounder" was released, and the pen was withdrawn from the paper thus making a "no mark" or a space. Because of this mode of operation the term "mark" has been used to mean the presence of current in a telegraph circuit be it hand keyed or Teletype. No current in the circuit was, of course, called a "space". (Incidentally, the recorded message consisted of a series of "dots" and "dashes" on the paper, and someone who knew the code was required to read the message.)

(The actual order was the reverse of that given here. The original telegraph used the "automatic recorder" which gave a series of marks and spaces on the strip of paper. Someone who knew the code had to read the "recorded" message. As time went on, those who read the message from the paper strip found that they could "read" the message as it was received by listening to the clicks of the "recorder"- hence, the recorder was dropped and a simple sounder was substituted.)

Before continuing with a description

of hand-keyed telegraph circuits, it will be shown how a Teletype machine fits into the scheme of things.

THE TELEPRINTER

A discussion of a teleprinter requires a separate, detailed description for each model. However, such a description would, at this point, only serve to confuse the issue.Therefore, we will take an almost over-simplified approach in order to discuss what the device does without burdening the reader with the "how" details. Some poking and peering into the innards of a teleprinter should answer a lot of questions once the "what is it supposed to do?" is answered.

There is a great similarity in outward appearance between a teleprinter and a typewriter. There are some things in common between these two devices, but the similarity soon ends when the innards are examined. In a typewriter, there is a more-or-less direct connection between each key on the keyboard and the type bar in the typebasket. When a key is depressed, the corresponding type bar is actuated.

An inspection of a teleprinter will reveal that for all practical purposes, a teleprinter is two separate machines having in common only the motor, the base, and the cover. One of the "machines", called the "keyboard" or the "keyboard-base", is composed of the keys and some device for translating the characters on each key into an electrical signal. The translation is done, commonly, by means of a mechanical arrangement that "tells" the distributor which key has been depressed. The distributor is, in effect, nothing more than a set of contacts operated by a motor. The contacts open and close at a fixed rate dependent upon the "speed" of operation (which is determined by the motor speed), and in a pattern depending upon the character or letter being sent. The distributor simply replaces the telegraph key in the circuit shown in Figure 1, as shown in Figure 2.

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The keyboard essentially replaces the telegraph key, but in addition, the "code" to be used is "stored" in the keyboard rather than in the operator's head. For example, when a manual-telegraph operator wants to send the letter "R", he, must translate "R" into a code combination of dots, dashes, and spaces and then operate the telegraph key in that code sequence. When using a teleprinter, the operator only has to know where the "R" key is located. He then depresses the "R" key and the teleprinter takes over from there; it translates "R" into the code corresponding to that letter and opens and closes the contacts corresponding to that code. (Incidentally, lest the reader be misled, the code used for hand keyed telegraphy and the code used for Teletype are not the same. This will be discussed later.)

The "other machine" under the cover is a decoding and printing mechanism. It is driven by a motor and operated by means of an electrical signal applied to the windings of a magnet. This magnet simply replaces the sounder in a manual circuit. The magnet operates, mechanically, a device known as a selector that translates or "decodes" the incoming signal and determines what letter or character is to be printed. Therefore, in effect, the printer receives the code, decodes it, and prints the corresponding character automatically, whereas with a manual system an operator is required to receive, decode (mentally), and write the character.

Again, it should be stressed that a teleprinter is essentially two independent devices. In fact, it is possible to "split" the machine and send something from the keyboard while receiving something else on the printer. (Of course, it is also possible to have the two portions connected and have the printer print something other than what is being "typed" on the keyboard; this is known as "trouble".)

Thus far we have a great similarity between manual and "printing" telegraphy. There is one major difference however: The code that is used.

THE CODE

Perhaps a little insight into why the teleprinter code is the way it is, or least why it is not the same code that is used for manual telegrphy can be obtained as follows.

Figure 3 (a) shows two manual telegraph characters and Figure 3 (b) shows what they would look like when viewed on an oscilloscope where current flowing corresponds to a "mark" and no current flowing corresponds to a "space".

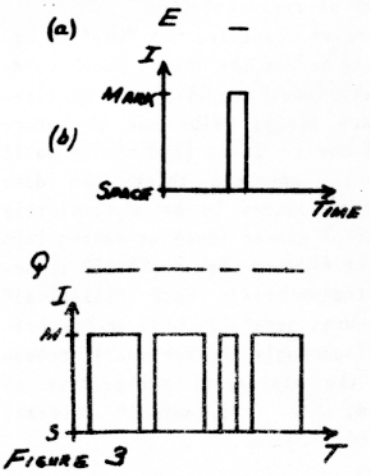


FIGURE 3

The code used for hand keyed telegraphy is a rather ingenious combination of short and long "marks" and "spaces". The long marks are called dashes and the short marks dots.Short spaces are used between the marks within a single character, medium-length spaces are used between characters (letters), and long spaces between words. Also, the code is set up in such a way that the more frequently used letters are composed of relatively short combinations of marks and spaces (the letter E is just one short mark) while the infrequently used characters are composed of many long and short spaces (the letter Q is composed of one long mark one short space, one long mark, one short space, one short mark, one short space and one long mark; no wonder it was so hard to get that CW speed up!)

This code used for hand keyed telegraphy is suitable for operation by a person when sending to a person, but if it were to be used between two machines a major problem would start. As mentioned, the hand keyed characters are composed of many different length combinations of marks and spaces and the overall character length (the time to send a complete letter) varies greatly from letter to letter- for example, the letter "Q" requires 13 times as long to send as does the letter "E". This variable character length is a desired (or at least a not undesirable) situation when people are doing the operating, but think of the problem in devising a machine to do this! The sending "machine" would be relatively easy to construct, but the receiving "machine" would be something else. Why? Mechanical devices inherently are easiest to construct and work best when a constant, fixed length of time is required for the machine to so something. Feeding a mechanical thing a source of information that may vary over a 13:1 range (actually more if the digit 0 is considered) and then expecting it to digest that and always give a single response (operating one type bar) is a bit much! Therefore, the answer was/is a completely different type of code that always uses the same length of time to send a character regardless of the particular character being sent.

A code that always uses the same length of time to send a character regardless of the character is the Murray code (the code used by teleprinters.) It consists of five even length data bits (mark or space), and always five, regardless of the character. Because every character is always composed of five marks and/or spaces of even length it is "naturally" suited to operation from/to a mechanical device. Because there are five portions to the signal, there are only 32 characters posibble. (2X2X2X2X2 equal 32.) This explains why a teleprinter has only 32 keys and why the arrangement of keys has to be somewhat different from that of a typewriter.

THE MURRAY CODE

Before commencing with the Murray code, let's review what was just discussed. In the case of manual telegraphy, the person who is sending translates the letters to be sent into a code which he sends by opening and closing a circuit with a telegraph key. The person receiving receives the message by listening to the sounder which makes a click every time the circuit is opened and closed by the telegraph key at the sending end. The "receiver" (the person receiving) translates the series of clicks into letters and writes them down. The basic objections to this system are the slow speed and the requirement for a skilled operator to be present at each end of the circuit.

In the case of printing telegraphy (Teletype), the person sending depresses a key on the keyboard corresponding to the letter to be sent; this letter is mechanically translated into the opening and closing of contacts. These contacts replace the telegraph key. At the receiving end, a magnet operates and releases an armature in response to the contacts at the sending end, and the armature, in turn operates a selector which translates the openings and closures into the letter that was being sent.

The discussion ended with the concept that a different code than the one used with manual telegraphy was needed for use with teleprinters because a teleprinter, being a mechanical device, requires a code of uniform length regardless of the character being sent.

All printing telegraphy, until recently, used the five element Murray code. Although commonly called the Baudot code, the code actually used by Amateurs, by law, is the CCITT International Telegraph Alphabet #2 which is the Murray code. For further details see: RTTY JOURNAL November 1974 page 12-13, or PRINCI PALS OF TELEGRAPHY (Teletypewriter), NAVSHIPS 0967-255-0010, S.D. Catalog No. D219.8: T23. (Amateurs are still required to use it by law, but commercially it is rapidly becoming extinct.) The code is given in Table 1. Each row lists a separate character (or pair of characters) and each column corresponds to a "timeslot" or a "bit". The M in a particular location indicates that a mark is sent at that time and an S indicates a space.

In most cases, there are two characters corresponding to each row.This is necessary because there are only 32 code combinations available in a five element code. However, there are more than 32 characters that one would like to send. Therefore, most of the code combinations have to be used for two things. (What the two characters are may vary greatly from machine to machine. This will be discussed later.) As an example, the first row lists "A" and "-". Which is meant when the combination MMSSS is sent?

The answer is relatively simple. Why on a typewriter do some of the keys have just one character and some have more than one? For example, the "7" key also has "&". The answer, when considering a typewriter, is to keep the number of keys to a minimum. The answer, when considering a teleprinter, is that only 32 keys are permitted. The next question is: How do you tell a typewriter

whether it is to print a "7" or an "&"? By shifting. There is a subtle point here. On a typewriter there are two kinds of shifts: 1) Locking, and 2) Non-Locking. On a teleprinter there is only one type: Locking. The shifting is done by hitting the FIGS or LTRS keys. When the LTRS key is depressed, the receiving machine performs a "stunt" rather than typing something: this stunt locks the printer in the necessary position to print the letters and characters appearing on the lower portions of the keys or the letters and characters appearing on the left side of the left column in Table 1.

When the FIGS key is depressed, the code sent from the keyboard is translated by the receiving machine to shift and lock into the position that will type what is on the upper portion of the keytops or what is shown in the right side of the left column in Table 1. Once the receiving printer is in FIGS it will remain there forever or until a LTRS is received. (Some printers are equipped with a "down-shift on space" arrangement whereby they shift to LTRS when LTRS or a character space is received. This is done for certain practical reasons that will be described later.)

THE ALPHABET

The FCC states in paragraph 97.69 (a) of the Rules and Regulations: "A single channel five-unit (start-stop) teleprinter code shall be used which shall correspond to the International Telegraphic Alphabet No.2 with respect to all letters and numerals (including the slant sign or fraction bar) but special signals may be employed for the remote control of receiving printers, or for other purposes, in "figures" positions not utilized for numerals. In general, this code shall conform as nearly as possible to the teleprinter code or codes in common commercial usage in the United States." Table 1 gives the CCIT Alphabet No. 2 referred to above.

The arrangement of most of the characters other than the letters and numerals varies greatly from machine to machine. The reason is that different users have different requirements. Ten of the "standard" codes can be found on page 845 of REFERENCE DATA FOR RADIO ENGENEERS,4th edition, IT&T, 1956.

THE CODE ELEMENTS

Let's examine the meaning of the M's and S's in Table 1. Take, for example, the row in Table 1 corresponding to the letter "Y". Going across the row from left to right, the letters MSMSM appear. This means that when the "Y" key on a keyboard is depressed, the keyboard sends a mark, a space, a mark, a space and a mark in that order. It sends them by closing, opening, closing, opening and closing the keyboard contacts. If an oscilloscope were placed in series with the contacts, a pattern as shown in Figure 1 would appear.

Now look at the "A" row. The letters MMSSS appear. This means that the letter "A" is sent by sending a mark, a mark, a space, a space and a space. The pattern appearing on an oscilloscope would be shown in Figure 2. This may appear simple enough, but a little reflection may reveal two problems: 1) How does the receiving machine know when the first mark ends and the second begins. and 2) When does the first mark begin? The answer to both these questions have some subtle implications.

TABLE 1

INTERNATIONAL TELEGRAPHIC ALPHABET NO.2

CHARACTER	TIME SLOTS				
	1	2	3	4	5
A -	M	M	S	S	S
B ?	M	S	S	M	M
C :	S	M	M	M	S
D Who RU	M	S	S	M	S
E 3	M	S	S	S	S
F	M	S	M	M	S
G	S	M	S	M	M
H	S	S	M	S	M
I 8	S	M	M	S	S
J Bell	M	M	S	M	S
K (	M	M	M	M	S
L)	S	M	S	S	M
M .	S	S	M	M	M
N ,	S	S	M	M	S
O 9	S	S	S	M	M
P 0	S	M	M	S	M
Q 1	M	M	M	S	M
R 4	S	M	S	M	S
S '	M	S	M	S	S
T 5	S	S	S	S	M
U 7	M	M	M	S	S
V	S	M	M	M	M
W 2	M	M	S	S	M
X /	M	S	M	M	M
Y 6	M	S	M	S	M
Z	M	S	S	S	M
Line feed	S	M	S	S	S
Carriage Ret	S	S	S	M	S
LTRS	M	M	M	M	M
FIGS	M	M	S	M	M
Space	S	S	M	S	S
Blank	S	S	S	S	S
	-*	*-			

In order to answer the first question, let's ask another question: When you copy a CW signal how do you know the difference between a dot and a dash? A dash is three times as long as a dot. You use a "mental clock" when receiving CW; you can tell whether they are dots or dashes by how long they last.

The receiving mechanism in a teleprinter also employs a "clock" or timing mechanism. The machine "knows" how long a mark is supposed to be. If a mark lasts "too long" it must be another mark!

The timing situation with printing telegraphy is more severe than it is with CW. When receiving CW you only have to be able to tell the difference between marks that differ in length by ratio of 3 to 1. By looking at Table 1 it can be seen that the characters E, A, U, K, and LTRS contain 1, 2, 3, 4, and 5 successive marks, respectively; the receiving teleprinter must be able to "time" with enough precision to distinguish between these five characters. The receiving machine can perform this feat only by running at exactly the same speed as the keyboard on the sending machine.

The same discussion regarding successive marks can be applied to successive spaces. Again, the answer is that the receiving machine must run at the same speed as the transmitting machine in order to accurately time the signal and thus correctly decode it.

In Amateur telegraphy, the length of a "time slot" (a single mark or a single space) is 22 ms (0.022 seconds). For example, in the oscilloscope pattern in Figure 1 each mark and each space is exactly 22 ms long. In the pattern shown in Figure 2, the mark is 44 ms (2 x 22) long and the space is 66 ms (3 x 22) long.

Now to question 2. On a letter that starts with a mark, such as "A", what comes before the mark? An obvious answer, if we consider CW, is: A space. Therefore, we could say: If a space exists before a character, the beginning of any character is indicated by the transition from a space to a mark. Right? Well, try this: What does Table 1 give as the code for "C"? SMMMS. Now, if the beginning of a character is indicated by the start of a mark, when does the letter "C" begin? The answer to this paradox is that something must be sent before every character in order to tell the receiving machine that a character is coming. Before describing how this is done, a "peculiarity" of printing telegraphy must be described. Therefore, we will wait until Part 3 for the description. We will say, however, that both a mark and a space must preceed a character.

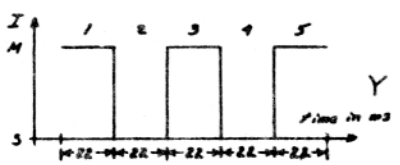


FIGURE 1

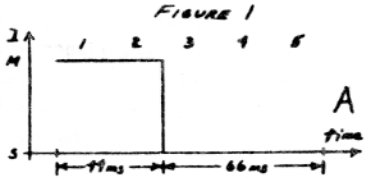


FIGURE 2

SUMMARY

The five-element Murray code was described. In order to obtain more than 32 characters it is necessary to use some code combinations for more than one character. This is done in a manner analogous to that employed on a typewriter, by shifting the machine. Most of the keys are used for two separate characters. The shifting is done by means of the LTRS and FIGS keys.

Because the receiving machine must "time" the incoming signal in order to decode it, the two machines must run at exactly the same speed. Because half the characters in the Murray code start with a mark and the other half with a space, the receiving machine must be told when a character starts. In Part 3, the method for telling the receiving machine when a character starts will be described.

START AND STOP PULSES

It was shown that it is necessary for the receiving machine to "time" the signal being received. The timing process requires that the sending and receiving machines operate at exactly the same speed. It was also shown that half the characters in the Murray code start with a mark and the other half start with a space. Therefore, some means of telling the receiving machine when a character starts must be employed.

In order to describe how this is done, a "peculiarity" of landline telegraph practice must be discussed.

TWO-WAY TELEGRAPHY

Because wire is expensive, it is desirable to use a single wire for manual telegraphy. Figure 1 shows how this is done. At each end of the circuit there is a telegraph key and a sounder in series. If a simple key that is normally open was used at each end, neither party could send because the circuit would always be open. If however, there were a switch across each key, and the switch was kept closed when not sending, the circuit could be opened by either party when he wanted to send a message and the circuit would be interrupted by his key. In this manner it is possible to have a two-way circuit with only a single wire. (Simultaneous two-way traffic could not be handled by this method, of course.)

Another advantage of the circuit being described is that other stations can be inserted into the loop (always in series) and so long as all keys are shorted while not sending, the circuit will always be continuous and any person desiring to send can "unshort" his key and send to all other stations.

Two teleprinters can be arranged for two way operation (not simultaneous two-way) by connecting them in a manner similar to the one described. See Figure 2 and compare it with Figure 1.

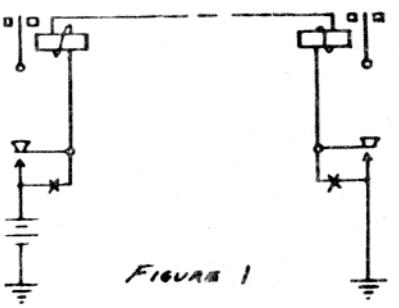


FIGURE 1

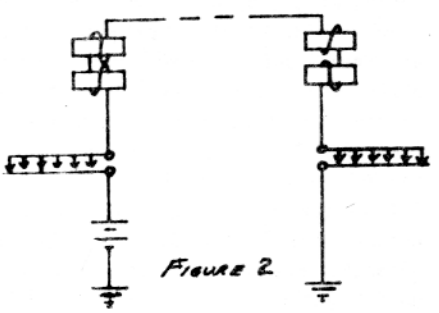


FIGURE 2

On each machine the selector magnets and the keyboard contacts are put in series. The same problem with manual telegraphy occurs here. How can one person send to the other if the circuit is opened by the keyboard contacts on the other machine? The answer is that the keyboard contacts are automatically closed when no one is "typing" on that keyboard. In other words, when the machine or the circuit is not being used, a steady mark is being sent. Therefore, teleprinters are arranged to have a steady current in the selector magnets when there is no message.

The standard schematic symbol for a teleprinter keyboard shows six contacts. One is shown closing the path. The other five are shown open. The

five that are alike represent the contacts that form the five portions of the Murray code. The one that is closed is used to form the "stop pulse" to be described later and is the same contact that is closed when the keyboard is not in use.

The "peculiarity" of printing telegraphy is that something (a steady mark) is being sent when nothing (no character) is being sent.

THE START PULSE

As described above, the idle condition of a Teletype circuit is indicated by a steady mark. A steady mark is also used between characters. The receiving teleprinter, therefore, is idle when current is flowing in its selector magnets. When a character is to be sent, the keyboard contacts open the circuit, thus sending a space. The receiving printer is therefore notified that a character is coming when a space is received after a steady mark. This space is called a "start pulse". This start pulse starts the timing sequence in the receiving printer. The start pulse is the same length as the elements of the Murray code, 22 ms.

In Table 1 we could have added a column before Column 1 labelled "Start", but because it would have an "S" entry in it for every row, it was not shown.

The start pulse completely resolves the paradox mentioned. Because every character is preceded by a space (the start pulse) and that is always preceded by a mark, the beginning of every character is uniquely defined.

THE STOP PULSE

We could have also raised the question: When does a character end? This is a natural question because half the characters in the Murray code end in a mark and the other half end in a space. One answer that could be given is: 132 ms after the beginning of the start pulse. Another, and perhaps better, answer is: At the beginning of the stop pulse.

It was mentioned previously that the idle or between character condition is a steady mark. Therefore, at the end of any Murray character a mark must be sent to indicate the end of the character. In Table 1 we could have added a column after column 5, labelled it "Stop", and put an M in that column on every row; this was not done because the entry is always an M.

The stop pulse not only signals the end of a character and prepares the receiving printer to detect the beginning of another character but also acts as a buffer between characters. If the stop pulse were not used, it might be possible to send characters so rapidly that the receiving printer could not tell when one character had stopped and the next one began.

The stop pulse is unique (when compared to the start pulse and the five element pulses) in that it has a definite minimum length but an indefinite maximum length. The stop pulse starts at the end of a character and ends when the next character is sent. When is the next character sent? This depends upon the person at the keyboard.

There are two standard minimum lengths for a stop pulse. On Western Union machines it is the same as the other pulses: 22 ms. Therefore, Western Union machines are called "7.0-unit" machines because the code they send is composed of seven even-length elements. Bell System machines have a stop pulse with a minimum length of approximately 31 ms. Because 31 ms is approximately 1.42 times 22 ms, and because the other six elements are 22 ms long, the Bell System machines are called "7.42-unit" machines.

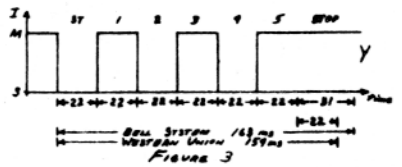


Figure 3

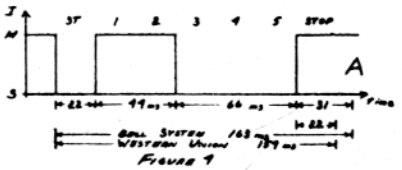


Figure 4

The current waveshape occurring when the letters "Y" and "A" are sent are shown in Figures 3 and 4. These are the same as shown in Figures 1 and 2, but contain, in additon, the start and stop pulses. The length of the individual elements as well as the complete character length are shown for Western Union and Bell System machines. The mark occurring before the start pulse is the end of the stop pulse of the preceding character and may be any length greater than the minimum length corresponding to the keyboard being used. The stop pulse shown at the right of the figures ends whenever the next character is sent. Its minimum length is indicated.

We would like to mention at this point, that although Bell System and Western Union machines are 7.42 and 7.0-unit, respectively, they are perfectly compatible. The only difference is that on a Bell System keyboard the minimum interval between successive characters (the minimum length of the stop pulse) is 42% longer than it is on a Western Union keyboard.

An excellent article regarding the 7.0 vs. 7.42-unit codes can be found in the RTTY JOURNAL, 1967 March, p.3. This article is a reprint of "Teleprinter Codes: 7 Unit Versus 7.42," F.W. Smith, Western Union Technical Review, 1954 October.

OTHER SPEEDS

For completeness, we would like to mention that amateurs may also employ 67, 75, and 100 WPM speeds. In addition, commercial stations use the 5-element Murray code described here and others use an 8-element code. "The 8-element code used in commercial service at 100 or 150 WPM operation is called ASCII.

SPEED

The term "speed" when used in connection with printing telegraphy usually means the number of words per minute that the equipment can handle. A word is defined as five characters plus a character space. Western Union characters are 7.0 units or 7.0 X 22

ms = 154 ms long. Therefore a Western Union "word" is 6 X 154 ms =924 ms= 0.924 seconds long. Because there are 60 seconds in a minute, a Western Union machine can send or receive 60/0.924 = 65 words per minute. There fore, Western Union machines are called "65-Speed" machines.

Bell System keyboards have a character length of 7.42 X 22 ms = 163 ms or a word length of 6 X 163 = 0.978 seconds. 60/0.978 = 61.3 words per minute. Therefore, Bell System machines are called "60-Speed" machines.

BAUD

The Baud or the "Baud rate" is defined as the reciprocal of the shortest element length measured in seconds. For both Western Union and Bell System machines operating at 65 and 60-speed, respectively, the shortest element length is 22 ms. Therefore, the Baud rate1/0.022= 45.45 Bauds.

SUMMARY

The need for the start and stop pulses were discussed. The start pulse, always a space, indicates to the receiving machine that a character is coming and starts the timing sequence in the receiving machine. The stop pulse is used to end a character and to give a steady mark in preparation for the next character. The stop pulse also acts as a buffer between successive characters to enable the receiving machine to prepare to receive the next character.

It was also shown that Western Union and Bell System machines differ in the minimum length of the stop pulse they send, but that this difference in no way affects their compatibility. The speed of operation in words per minute was calculated and the Baud was defined.

MAKING A TELEPRINTER GO

We have described some of the principles of printing telegraphy. It seems best, at this point, to show how to connect a teleprinter for obtaining local copy. By doing this, it should be possible for a beginner to "play" with this machine and to illustrate, first hand, some of the things we have discussed.

CONNECTING A MACHINE

The method used to make a printer work for local copy is simple: 1)Supply the motor whatever power its name plate asks for, and 2) Connect in series a DC power supply, a resistor, a millimeter, the keyboard, and the selector magnets. (The power supply should be capable of supplying from 110 to 300 volts when 60 mA is flowing) Adjust the resistor until 60 mA is flowing, turn on the motor, and "hit" a key on the keyboard.

Assuming all works, try proving or illustrating a few of the things we have talked about. For example. Learn where the keys are just what the LTRS FIGS, CAR RET, and LF keys do and how they do it. Poke judiciously, at the machine's innards and discover what a mechanical marvel it is. Try placing a 10 ohm resistor into the loop, connect an oscilloscope across the resistor, and look at the waveforms when various characters are sent.

If any difficulties are experienced perhaps the following will help:

Before continuing, we would like to editorialize: Some "experts" state that the first thing an amateur should do when he obtains a teleprinter is rip out the wiring and, unless the motor is a synchronous motor, throw it away!! We say NONSENSE!! You may have to make some minor modifications in the wiring, but be very cautious. More on this later. As far as the motor goes, if the motor is changed, the gears will probably have to be changed also. This involves quite a bit of work. If, after you have ripped out all the wiring and replaced the motor and gears, what happens if the printer won't work? The first thing to do is determine whether it worked when you obtained it. How can you possibly know if you instananeously ripped it apart?

THE MOTOR

Look at the name plate on the motor. If the speed is 1800 or 3600 RPM it is probably a synchronous motor. If it says it is, it is.Therefore, if it is a synchronous motor supply the voltage it requires (probably 120 V at 60 Hz). If the printer has a lot of auxiliary apparatus with it, it would probably be best to trace the wiring and carefully isolate the two leads going to the motor, writing down just what leads were disconnected from where. You will probably want to reconnect them later so make sure that you know just what you did disconnect. Our aim at present is just to get the machine printing local copy.

If the machine has a DC govenor-controlled motor, there is some auxiliary apparatus such as the governor, resistors and capacitors. Trace the wiring and determine where to apply power. If at all possible, build, even if it is only a temporary "hay wired" deal, a power supply to run the motor. (Do not use the supply for loop to run the motor.) You will need about 110V DC at 1A. This may seem a bother, but it is better to try using the DC motor even if it is for a few minutes of operation, than it is to rip away and possibly foul things up.

For methods suitable for DC motor power see: "Some Notes on the Western Union 28 Simplex Printer", Guentzler, RTTY JOURNAL, 1966 March,pp.3-4; and "teletype-Printer Noise Redution", R.B.Gold, QST, 1966 August, pp.71.

One further comment about motors: A synchronous motor will run at only one speed and that speed is determined by its physical construction and the frequency of the applied power. Governor-controlled motors (AC & DC) can operate over a wide range of speeds. Even when the governor is removed, the speed may vary depending upon the mechanical load placed upon the motor and the applied voltage. The nameplate on the governor-controlled motor is not the speed at which the motor is supposed to be operated when governor-controlled: it is the "nominal" speed when the "nominal" mechanical load and voltage is applied. For example, on some Western Union machines with governor-controlled motors the nameplate on the motor stated 1725 RPM, but the actual desired speed as controlled by the governor is 1682 RPM. On others, the motor nameplate stated 2200 RPM, but the governed speed was 2104 RPM.

THE SELECTOR MAGNETS

There are two basic types of selectors and, of these two types, one has two possible ways to connect the magnets. These are summarized as follows:

1) Pulling magnets (60 mA, series only)
2) Holding magnets
   a) Series - 20 mA
   b) Parallel - 60 mA

What type selector does your machine have, and how should the magnets be wired? Perhaps the following will help you decide:

Older machines were equipped with a selector mechanism that was operated by the selector magnets pulling an armature which was fairly massive and required a relatively large pulling force. Consequently, selectors using this type armature are called "pulling type" selectors and the two magnets must be wired in series and must be supplied 60 mA for proper operation.

On newer machines and newer versions of the older machines, the selector was redesigned so the armature is moved, at least indirectly, by the motor rather than by the magnets. The armature is moved up to the magnets and then released, if no current is in the magnet coils, the armature falls away. Consequently, this type selector is called a "holding-type" selector and much less magnetic force is required. Therefore, the coils can be operated in parallel and 60 mA supplied to the combination or they can operated in series and only 20 mA is required. For various reasons, although the lower current sounds attractive, the 60 mA parralel operation is recommended.

Now comes the rub. What type selector do you have and how should you connect the magnet coils? The obvious answer is: Ask someone who knows to look at your machine and tell you what to do. Next choice is to look at someone else's machine and see how it is constructed and connected. Last choice (from an ease of doing something standpoint) is to find out all by yourself.

Trace out the wiring connected to the selector magnets. If the coils are in parallel, you probably have a holding-type selector connected for 60 mA operation. If the coils are in series, try operating the machine with 60 mA in the coils as we described at the begining (have motor operating and "type" something.) If it operates, and it probably will, slowly decrease the loop current until operation ceases. If it stops at about 30 mA, you have a pulling-type selector and you must use 60 mA with the coils connected as they are. If operation continues down to about 10 mA loop current, you have a holding-type selector connected for 20 mA operation; reconnect the magnets so they are in parallel, adjust the loop current for 60 mA, and try operating the machine. If it works, fine; if it does not work, you have phased the coils improperly when you were reconnecting them. Reverse the leads to one magnet and try it again. It should now work.

SPEED

At what speed does your machine operate? We have discussed some of the "standard" operating speeds and also made a strong case for the fact that the transmitting and receiving machines must operate at the same speed. When you are operating your one machine by itself, it is operating at the "proper" speed, regardless of what that speed is, because the keyboaard and selector are geared to each other and therefore regardless of the actual speed, they are operating at the correct relative speed. However, once you try to transmit to or receive from some other machine, you must operate your machine at the proper speed relative to the other machine. Therefore, the actual speed is unimportant when making local copy, but will become vital once you "get on the air".

There are many ways to determine the speed of your machine. Some are much better than others: we will mention some of them and let you pick the method best suited to your situation.

1. The keyboard shaft should rotate at 368 RPM and the selector shaft at 420 RPM on a Bell System "60-Speed" machine, and the keyboard shaft should rotate at 389 RPM and the selector shaft at 420 RPM on a Western Union 65 speed machine. Obtain a Strobotac and measure the speeds.

2. If the machine has a synchronous motor, count the number of teeth on the gears (or gear and pinion) and calculate the speeds of the keyboard and selector shafts. (See gears and things).

3. Connect your machine into a local loop with someone else's machine and send back and forth. If both machines can send and receive to/from each other, the speeds are probably correct.

4. Tune in an Amateur RTTY signal and see whether you can copy it. (We have not discussed this yet, but if you are far along, try it.) This is not the best test in the world. If you can copy, fine. If you can't there are many reasons other than improper speed that could be causing the trouble. Try several different amateur RTTY signals. Also try reversing the switch on your TU. Unfortunately, most commercial stations are not 60-speed, but if you look long enough you may find one. However, if you do find a commercial station that you can copy this may not tell you much because they operate at "standard" speeds of 60, 67, 75 and 100 WPM and which you are copying is debatable.

SUMMARY

Connecting a teleprinter to obtain local copy is relatively simple. Supply power to the motor, and connect in series a DC power supply, the keyboard, the selector magnets, a resistor and a millimeter.

Several possible causes of trouble were discussed. It was recommended that a teleprinter be operated "as received" if possible; this is desirable because, if nothing else, it indicates whether or not the teleprinter was in operating condition when received.

A concise summary of teleprinters was given in the 1971 March (pp. 8) and April (PP.8) issues of the RTTY JOURNAL.

ADDENDA FROM ORIGINAL ARTICLE

The newer machines (M 32 on up), use a more complicated arrangement for operating the selector magnets. In the older machines (M 28 and below), the magnets were inserted

directly into the loop as already described. The inductance of the magnets presented bad transient problems that tended to distort the loop current waveform and thus cause errors in copy. The inductance problem could be mitigated by using high voltages in the loop (130 V or higher). The high voltages placed a burden upon solid state devices. Consequently, starting with the M32, the magnets have been designed to operate from about 12 V at 500 mA. They cannot be used directly in a 60 mA loop. The machine comes equipped with a solid state magnet driver (SMD) that requires 60 (or 20) mA at its input. Thus, its input is inserted into a loop in the same manner that the magnets were inserted in the older machines. The output of the SMD drives the 500 mA magnets. Therefore, there are acturally three basic types of selectors.

TRANSMITTING A RTTY SIGNAL

It may appear a bit backward to discuss transmitting a signal before the process of receiving is considerd because all amateurs receive before they can transmit (some for years!). However, if you know what you are trying to receive, it should be easier to understand why the receiving equipment is constructed and operated as it is.

TYPES OF SIGNALS

There are many ways to transmit a RTTY signal.Three simple methods are:

1. On-off keying
2. Frequency shift
   a. RF (FSK)
   b. Audio (AFSK)

The first method listed is the most obvious, especially when one is familiar with CW and the analogy between CW and RTTY that was described previously. In a simple telegraph loop, the signal is sent by opening and closing the keyboard contacts; because the keyboard contacts just open and close, it should be possible to substitute the keyboard contacts for a telegraph key on a CW transmitter and have "instant" RTTY.

This scheme will work and has been employed, but, although it represents the ultimate in simplicity for the "sender", the "receiver" may be faced with a serious problem. With this simple scheme, a mark is something and a space is nothing. What happens, when a burst of static somes along? A burst of static is something, therefore the receiving equipment mistakes the static for a mark and prints an error; the simple on-off scheme is prone to errors. (One might argue that CW is amazingly free of such problems, and on-off RTTY should be also. However, when employing CW, there is one additional item that is not employed in RTTY. It is a mass of grey matter located between a pair of ears. It is capable of doing things that no electronic circuitry can come close to matching.)

FREQUENCY SHIFT KEYING

For the time being, we will ignore the differences between audio frequency shift keying (AFSK) and carrier frequency shift keying (FSK) and discuss their common features.

In a frequency shifting scheme, something is always being transmitted; i.e., the transmitter is always sending RF into the antenna. For example, whenever a mark is to be sent, the output from the sending end is a particular frequency, and, when a space is to be transmitted, a different frequency is sent. Because there is always a mark or a space being sent, the receiving equipment has a much easier time deciphering the signal.

This will be explained fully later, but a brief explanation follows:

The receiving end can copy from mark only because a knowledge of the marks implies that there are spaces between the marks. If only spaces are received, marks must be in the "gaps" between the spaces. Therefore, if both marks and spaces are sent, the receiver can use either one and obtain all the information sent. If bursts of noise are present, the receiver can employ a simple scheme where it uses both marks and spaces in such a manner to reduce its sensitivity to interference.

FSK

Carrier frequency shift keying (FSK) is commonly employed on the HF bands. FSK is called F1 modulation.

One method of carrier frequency shift generation is to place a small capacitor across the oscillator tank circuit. The capacitor is then connected and disconnected by the keyboard contacts.

Because of the unsuitability of conducting RF into the keyboard contacts, a few simple components are placed between the keyboard contacts and the frequency-shifting capacitor. These components are typically a capacitor, a diode, and RF choke, and a few resistors. The diode is used as a switch to connect and disconnect the shifting capacitor. The other capacitor and the RF are used as a simple low-pass filter to block RF from the contacts.

Again, an FSK signal can be generated by connecting and disconnecting a small capacitor across the oscillator tank in a transmitter in response to the opening and closing of the keyboard contacts in the teleprinter.

Normally, the mark frequency is lower than the space frequency.

With the advent of highly stable transmitters and receivers, the space tone is usually 170 Hertz lower than the mark frequency. Frequency shifts up to 850 Hertz are occasionally encountered on the Amateur frequencies.

Typically, space is 850 Hz lower in frequency than mark. (By law it must be less than 900 Hz). Some amateurs are using a shift of 170 Hz; this is called "narrow shift". Narrow shift has many advantages compared

to 850-shift, and only one disadvantage; the disadvantage is that both the transmitter and receiver must be stable (free from frequency drift problems).

AFSK

On 6 meters and above, audio frequency shift keying is permissable. (FSK is also permissible).

AFSK is usually obtained in the same general manner as FSK, but the frequency of an audio oscillator is shifted. The output from the oscillator is fed into the audio input of a transmitter.

The most common method used to obtain AFSK is to build an audio oscillator whose output frequency is as high as possible within legal limits. Usually 2295 Hz is used. A capacitor can be placed in series with the keyboard contacts and the combination is placed across the oscillator tuned circuit. When the contacts are open (space), the output of the oscillator is 2295 Hz. When the contacts are closed (mark), the resonant frequency of the circuit is lowered because of the additional capacitance and the output frequency is lower. The most common frequency for mark is 2125 Hz (170 Hz lower than than space). (NOTE that Mark 2125 Hz. is the lower frequency and Space 2295Hz is the higher frequency for normal 170 Hz shift.)

The oscillator containing the shifting capacitor and usually a few other components including a diode to do the actual switching in order to keep the audio out of the keyboard contacts is called a keyer. The keyboard contacts are connected to the input of the keyer and the output of the keyer is connected to the audio input (microphone input) of an AM or FM transmitter.

When an AM tansmitter is used, the modulation is called A2. When an FM transmitter is used, the modulation is called F2. When a SSB tansmitter is used, modulation results in an output similar to FSK and is called F1.

(Note that an AFSK keyer into a SSB transmitter results in an output that looks like carrier frequency shift keying so long as the keyer is well designed and the SSB transmitter is adjusted properly.)

For specific circuits of AFSK keyers see: 1. THE NEW RTTY HANDBOOK, Byron Kretzman, pp. 102-3;2. "Audio Frequency-Shift Keying for RTTY", Irv Hoff, QST, 1965 June, p. 32ff; 3. "An AFSK Keyer", R.E. Guentzler, RTTY Journal, 1967 July-Aug., p. 9ff; 4. SEE AN AFSK KEYER.

SUMMARY

Because RTTY is sent over a local loop by simply opening and closing contacts, we will not attempt to discuss a specific FSK circuit at this point because the actual circuit to be used depends upon how the voltage used to operate it is obtained. This will be covered in detail later.

This method, called "Indirect FSK," will be covered later also.

It is possible to substitute the keyboard contacts for a telegraph key on a CW transmitter. This means of transmission is very difficult to receive except under very favorable conditions. A better method known as frequency shift keying requires the transmitter to be on continuously whether a mark or space is being sent. The carrier frequency can be shifted between two frequencies, one for space and lower frequency for mark (FSK or F1). On 6 meters and above a voice transmitter can be used and the frequency of an audio modulating signal can be shifted (AFSK, F2 or A2). With either FSK or AFSK the frequency can be shifted by placing a capacitor across the tuned circuit in the oscillators.

AN AFSK KEYER

We described the two principal methods used to transmit a RTTY signal: 1) Frequency shift keying (FSK). and 2) Audio Frequency Shift Keying (AFSK). It was shown that they are in some ways quite similar in that the frequency of an oscillator is shifted between two different frequencies as the contacts on the keyboard of a teleprinter open and close. In the case of frequency shift keying, the frequency of the oscillator within the transmitter is shifted. This is usually accomplished by slightly modifying the oscillator circuit within the transmitter.

In the case of audio frequency shift keying, the frequency of an audio oscillator is varied between two different frequencies as the keyboard contacts open and close. The output of the audio frequency shift keyer is connected to the microphone input of a voice transmitter (AM or FM). Because the AFSK keyer is not built into the transmitter, essentially any AFSK keyer can be used with any voice transmitter. (Of course, the input impedance of and level required by the tansmitter will have some effect upon the specific requirements of the AFSK keyer, but the restriction can be considered minor.)

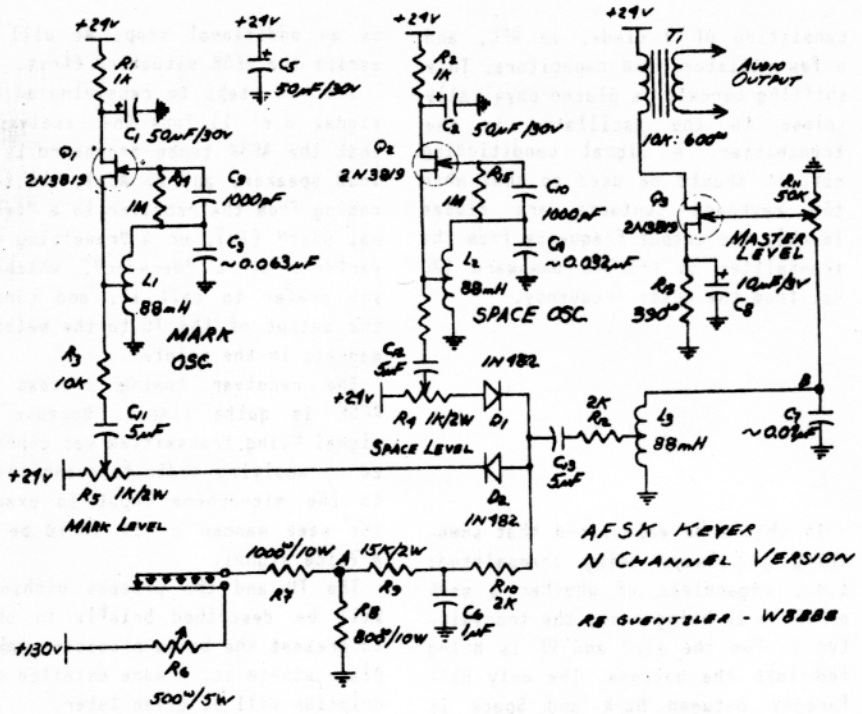
THE AFSK KEYER

Although an AFSK keyer can be built with a single oscillator and a capacitor placed across its tuned circuit to shift the frequency, more versatility and reduced keying transients can be obtained by using two separate continuously-running oscillators whose outputs are "gated" by the opening and closing of the keyboard. The two major advantages of separate oscillators (one for mark and one for space) are:

1) The frequency of each oscillator can be adjusted independently of the other, and
2) The levels of mark and space tones can be independently adjusted.

The circuit will be described briefly and then various portions of the circuit will be described in some detail.

The oscillators use the familiar Hartley circuit consisting of an 88 mH toroid shunted by the proper amount of capacitance to give the required 2125 and 2975 Hz. (wide shift) resonant frequency. The values shown for C3 and C4 are the approximate values required. The exact values should be determined by measuring the output frequency and adjusting the capacitors until the frequency is proper. The capacitors can be "varied" by shunting small mica capacitors across C3 and C4.



The oscillator transmitors are TI 2N3819's. These are N-channel junction field effect transistors. The resistors R1 and R2 and the capacitors C1, C2, and C5 are for decoupling. R1 and R2 can be used to measure the drain current on the transistors. It should be from 4 to 8 mA.

The keyboard is connected into a "loop" composed of R6, R7, and R8; the loop is fed from 130 V or higher. R6 is adjusted to give a loop current of 60mA. (Actually, R6 is not really necessary and the loop current does not have to be set to 60 mA unless a selector is also put into the loop. The selector is undesirable for reasons described later, but "force of habit" or good telegraph practice indicate that 60 mA is desirable.)

Assuming that R6 is present and it has been adjusted to give 60 mA loop current, during marking condition from the keyboard (contacts closed and 60 mA flowing in the loop) the potential at point "A" is approximately plus 48 volts; during the spacing condition (no loop current), the potential at point "A" is approximately 0 volts. This variable potential is coupled into the diodes D1 and D2 thru a delay network composed of R9, C6, and R10. The varying potential at point "A" causes one or the other of the diodes to conduct. For example, during a mark the potential at point "A" is 48 volts; this voltage causes diode D2 to conduct or gate the output from the mark oscillator into the output amplifier Q3. The output from the space oscillator will be blocked from Q3 because D1 is reverse biased.

During a space, the voltage at point "A" is approximately 0 volts causing D1 to conduct and D2 to open. Therefore, during a space the output from the space oscillator is connected to Q3 via D1 and the output from the mark oscillator is blocked from Q3 by non-conducting diode D2.

R4 and R5 control, independently, the levels from the two oscillators while R11 controls both levels simultaneously.

The network composed of R12, L3, and C7 is essentially a "simple-minded" band pass filter. The output stage is a common-source amplifier transformer coupled to the transmitter audio input circuit.

Capacitors C1 and C2 can be any value greater than 1 uF. C5 should be as large as possible.

It was found that the frequency of the oscillators changed less than 1 Hz when the supply voltage was varied from 18 to 26 volts. With stability that good, no regulation is required.

The diodes should be silicon junction diodes. This is desirable in order to get a good forward to backward resistance ratio with the magnitudes of oscillator and switching voltages available. We used the 1N482.

The switching delay network composed of R9, C6, and R10 can be changed if more diode current is required or if the time constant is considered too long. In the circuit shown, the total switching time is approximately 8 cycles at 2125 Hz or about 4ms. If the 1N482 is used, the network is optimum.

The "filter" network composed of R12, L3, C7, and R11 is tuned to resonate at approximately 2550 Hz. The best tuning procedure is to adjust the size of C7 so that the mark and space tones appear at the output at equal levels when R4 and R5 are wide open. The Q of the L3-C7 circuit is kept low by using the 50K potentiometer (R11) and the coupling resistor R12. This filter serves several purposes: 1) It cleans up any harmonics from the oscillators. 2) It removes the harmonics generated by the diodes during the switching interval when the diodes are partially-conducting, and 3) It helps remove the low frequency transients caused by the DC used to switch the diodes.

The 24 V power supply should be "stiff" so that the loop keying does not affect the keyer in a manner other than the desired one.

When wiring the unit, it is advisable to separate the wiring in the loop circuit from the remainder of the unit. This is desirable because "spikes" may be present in the loop due to bouncing contacts, etc., and

these "spikes" could get into the output and into the transmitter.

One note of caution: As is the usual case, too many selector magnets in the loop will cause spacing bias on the transmitted signal. The spacing bias can be reduced by decreasing the size of R8. The best way to eliminate the bias is to prevent it; i.e., don't put selector magnets in the keyboard loop!

CONCLUSION

We have just described a good AFSK keyer. It is slightly different from most others described elsewhere in that it uses two separate oscillators and the output from these oscillators is gated by means of two diodes.

We have had one of these units running 24 hours/day for over 6 years now and there has been no sign of deterioration in performance. (About 50,000 hours of continuous operation!)

RECEIVING RTTY SIGNALS

We described how an RTTY signal is transmitted. This was done before describing how to receive a signal because it was felt that it is easier to understand how to receive something if one knows what that "something" is. We will review the transmitting process and then describe the receiving process.

There are two methods used to transmit an RTTY signal. Both involve frequency shifting a signal. One method employs frequency shifting the carrier from a CW transmitter. The other method involves frequency shifting an audio tone which is applied to the microphone input of a voice transmitter (FM or DSB AM). The former method is called FSK and the latter method is called AFSK. Which method is used is dependent upon legal restrictions and/or technical problems. Generally, FSK is used on 10 meters and below, and AFSK is used on 6 meters and the above.

FSK is obtained by connecting the keyboard contacts to the oscillator circuit in a CW tansmitter. The connection is made thru a simple circuit consisting of a diode, an RFC, and a few resistors and capacitors. This shifting circuit is placed physically close to the oscillator in the transmitter. A signal conditioning circuit should be used so that when the keyboard contacts are closed (mark), the output frequency from the transmitter is shifted downward 170 Hz. from the space frequency.

It should be emphasized that something is always being transmitted; i.e., regardless of whether a mark or space is being sent, the transmitter is "on the air" and RF is being fed into the antenna. The only difference between Mark and Space is that the output or tansmitted frequency is slightly different.

AFSK is obtained by building (or buying) an audio oscillator that contains a shifting circuit similar to the one that was used in the FSK transmitter oscillator circuit. When a Mark is to be sent, the output from the audio oscillator is a given frequency (typically 2125 Hz). When a space is to be sent, the output from the audio oscillator is shifted upward in frequency. Usually, a shift of 170 Hz is used; therefore, if the Mark frequency is 2125 Hz, the Space frequency is 2295 Hz. The audio oscillator and its shifting circuit are called, collectively, an "AFSK Keyer" and this keyer is housed in a box that is physically separate from the transmitter. (That into the transmitter, while with AFSK the shifter and its oscillator are located external to the terminal.) The output from the AFSK keyer is connected to the audio input of an FM, AM or SSB transmitter (lower sideband).

THE BASIC RECEIVING PROCESS

Whether the signal to be received is FSK or AFSK, there are certain similarities in the receiving process. In the case of AFSK there are essentially two steps and with FSK there is an additional step. We will describe the AFSK situation first.

The two steps to receiving an AFSK signal are: 1) Tune the receiver so that the AFSK tones are heard in the loud speaker, and 2) Apply the tones coming from the receiver to a "terminal unit" (TU), or a "receiving converter", or a "decoder", whichever you prefer to call it, and connect the output of the TU to the selector magnets in the printer.

The receiver tuning process for AFSK is quite simple. Because the signal being transmitted was generated by applying audio-frequency tones to the microphone input in exactly the same manner as it would be for a voice signal.

The TU and the process within it will be described briefly in order to present the basis processes taking place within it. A more detailed description will be given later.

As mentioned above, the audio output from the receiver is fed into the TU. This audio signal is composed of a Mark tone at 2125 and 2295 Hz for a Space. Only one tone is present at any one time. Inside the TU is a pair of tuned circuits; one circuit is tuned to the Mark audio frequency and the other to the Space audio frequency. When a Mark tone is received there is an output from the Mark tuned circuit and none (or very little) from the Space tuned circuit. When a Space tone is received, there is an output from the Space tuned circuit and none from the Mark tuned circuit. The output from these tuned circuits is an audio frequency voltage (AC). These AC voltages are rectified (converted to DC) by a circuit similar to that used in a power supply. There is one rectified circuit connected to each tuned circuit. The diodes in one of the rectifier circuits are reversed from the way those in the other circuit are connected. Therefore, for example, when a Mark tone is received a positive DC voltage results whereas when a Space tone is received a negative voltage is produced. This DC voltage is too weak to directly operate selector magnets and is amplified. The amplification can be accomplished by means

of a polar relay, a vacuum tube, or a transistor. The amplified voltage is applied to the selctor magnets.

To summarize the AM or FM AFSK receiving process: The tones are received on an "ordinary-type" AM or FM voice receiver as would a voice signal. The tones coming from the receiver are fed into a terminal unit (TU). The TU separates the two tones, converts them to DC, and then turns on and off a DC loop connected to the selector magnets. The DC loop is turned on when a Mark tone is received and off when a Space tone is received.

RECEIVING FSK

The FSK receiving process involves three steps: 1) Tuning in the FSK signal, 2) Converting the FSK signal into an AFSK signal, and 3) Converting the AFSK signal into a DC loop signal by means of a TU.

The last step will be considered first because we have already discussed it. The TU used for FSK can be the same one used for AFSK so long as the tones applied to it are AFSK tones of the proper frequencies.

How do you get AFSK tones from a receiver tuned to an FSK signal? The answer is the same as the answer to the question: How do you get a tone from a receiver when receiving a hand-keyed CW signal? The answer is: Use the BFO in the receiver. When receiving a hand-keyed CW signal you are trying to listen to a single carrier or RF signal that is simply going on and off. By means of the BFO you (or, rather, the receiver) converts that single carrier frequency to an audio frequency. The pitch (or frequency) coming from the receiver is dependent upon the difference between the transmitted frequency and the frequency of the BF oscillator within the receiver, if the carrier frequency of the received signal varies, the pitch of the tone from the receiver varies. If you tune in an FSK RTTY signal, the tone coming from the receiver will change as the transmitted signal changes frequency. Therefore, the first two steps involved in receiving an FSK signal are more-or-less accomplished simultaneously.

Now come some problems that occur with FSK that do not occur with AFSK. In order to describe and understand these FSK problems, let's look at AFSK again. When a person is transmitting voice or AFSK on an FM or DSB AM transmitter, the audio frequencies he sends are determined by him. When you tune your receiver to hear his signal, you tune for maximum signal or least noise but in the tuning process you do not change the frequencies being heard. You merely optimize what you are hearing. In the TU the tuned circuits are tuned so that one gives maximum response to Mark tone and the other to Space tone. In order to greatly simplify what could become a messy tuning problem, certain standards have been set up for AFSK RTTY and one of them is that when using "170-shift" the Mark tone is always 2125 Hz and the Space tone is always 2295 Hz. Therefore, once you have built your TU you should not have to retune it everytime you receive an AFSK signal because "everyone" uses 2125 Hz. for Mark and 2295 Hz. for Space.

When you tune a CW signal, you tune for a combination of things including maximum signal and least noise. When tuning you also change the pitch of the signal. This pitch is not particularly important because your head contains a rather broadly-tuned circuit that will accept almost any pitch. When you tune an SSB signal you have a slightly tougher situation than with CW because you have to tune to get the voice frequency components in approximately their proper range in order to understand what the person is saying, but there is still some room for error and your head will compensate for it. However, the tuning is more critical than it is with CW.

Now back to FSK. When you tune in an FSK signal, your tuning determines the pitch of the received tones. If his transmitter or your receiver drifts, the pitch of the received signal changes as it does with CW or SSB. However, because the TU contains rather sharply-tunes circuits, the audio tones presented to the TU must match rather closely the frequencies to which the circuits are tuned. Therefore, when you receive an FSK signal you must tune for the proper pitch of tones and a slight drift in frequency at the transmitter or receiver may alter the frequency of the received tones enough to cause errors in the printed copy or prohibit copy.

For example, if either end drifts by 100Hz, the tones will change by 100 Hz, and this may be enough to prohibit copy. A change of 100 Hz at a frequency of 3,600 MHz is a change of one part in 36 thousand or approximately 0.003%. At ten meters a change of 100 Hz is approximately 0.0003%. This represents a pretty tight frequency tolerance.

Again, a problem with FSK reception is that the person receiving determines by his tuning what audio tones will appear from the receiver. This means that the tuning process is more difficult than with AFSK. Also, any drift in frequency at either end will directly result in an error in the tone output frequency from the receiver. With AFSK a tuning error is either totally unnoticed, or, at worst, may result in a change in noise level from the receiver.

Another problem with FSK. Also, any not as serious, is that by improper tuning you may end up with an "upside-down" signal. This is analogous to what happens when an SSB signal is tuned on the "wrong" side (trying to receive with the mode switch in "LSB" when it should be in "USB"). You might tune in the signal so that one tone is exactly 2125 Hz and the other is 2295 Hz. but get nothing but "garbage" from the printer. The problem is that Space is 2125 Hz and Mark 2295 Hz! (Incidentally, this could also be the fault of the transmitting station.) A simple remedy for this situation is to incorporate within the TU a "reversing" switch that permits the interchange of Mark and Space signals.

SUMMARY

We have briefly reviewed the two methods of tansmitting RTTY signals.

It was pointed out that when AFSK is received a voice type receiver is used and the tones being transmitted are heard in the loudspeaker. Tuning the receiver optimizes reception of the tones but does not change their pitch of frequency. The tones are fed from the receiver into a terminal unit (TU). The TU separates the tones by means of two filters or tuned circuits, converts the outputs of these filters into DC, and applys the DC to a loop keyer which operates the selector magnets in the printer. The loop keyer may be a polar relay, a vacuum tube, or a transistor.

When FSK is to be received, the receiver must receive the signal (obviously) and convert the FSK signal to audio tones or AFSK. (The conversion to AFSK is the same process used to receive CW or SSB.) Once the AFSK signal has been generated within the receiver a TU is connected to the output of the receiver as it was for a pure AFSK situation. The prime difficulty with receiving FSK is that the frequency of the tones appearing at the receiver output is dependent upon the tuning of the receiver, and precise tuning is required compared with the rather sloppy tuning required with AFSK. Also, any drift of the receiver or transmitter when using FSK will result in a shift of the frequency of the tones coming from the receiver, and even a relatively minor drift (when compared with AFSK or DSB AM voice) will be described in more detail next.

A SIMPLE TU

When an AFSK signal is received, the receiver (AM or FM) is tuned to the signal and the tones being sent are heard in the loudspeaker. The frequency of the tones is not affected by tuning the receiver; tuning merely optimizes for minimum noise. When a FSK signal is received, the receiver is operated as it would be for a CW signal (or more accurately, as it would be for an SSB signal). When the receiver is tuned, the FSK signal appears as tones coming from the loudspeaker. The tuning of the receiver affects the frequency or pitch of the tones as well as the relative amount of interference and noise. Therefore, the receiver must be tuned so that the FSK signal has exactly the right pitch.

In either case (AFSK or FSK), the tones coming from the receiver audio output are applied to the input of a TU. The TU has the job of distinguishing the Mark and Space tones, and, ultimately, opening a loop when a Space is received and closing a loop when a Mark is received. The loop is connected to the selector magnets in a teleprinter.

We are going to describe a simple TU in order to show how a TU converts the audio tones into the opening and closing of a loop. We have selected the Twin City TU for two reasons: 1) It uses vacuum tubes and will therefore be understandable to the maximum number of readers, and 2) it contains all of the absolutely necessary circuitry, but at the same time is simple enough to be easily understandable.

When looking at the circuit diagram it will be noticed that no component values are given. We did this because we are trying to remain neutral in the area of which TU is the best for a particular application. Anyone interested in building the Twin City TU can find it in: THE NEW RTTY HANDBOOK, Byron H. Kretzman, W2JTP, Cowan Publishing Co., 1962.

The circuit can be divided into several separate and essentially independent portions as follows: 1) input "amplifier" and isolation (T1, R1). 2) Limiter (C3,R2, V1, R3, R4) 3) Amplifier (C4, R5, R6, V2, R7),4) Space and Mark filters (C5, R8, L1, C1, L2, C2), 5) Space voltage doubler reactifier (C6, CR3, CR4, C8), 6) Mark Voltage doubler rectifier (C7, CR5, CR6, C9), 7) DC amplifier (R9, R10, R11, V3, R12),and 8) Loop keyer (K1).

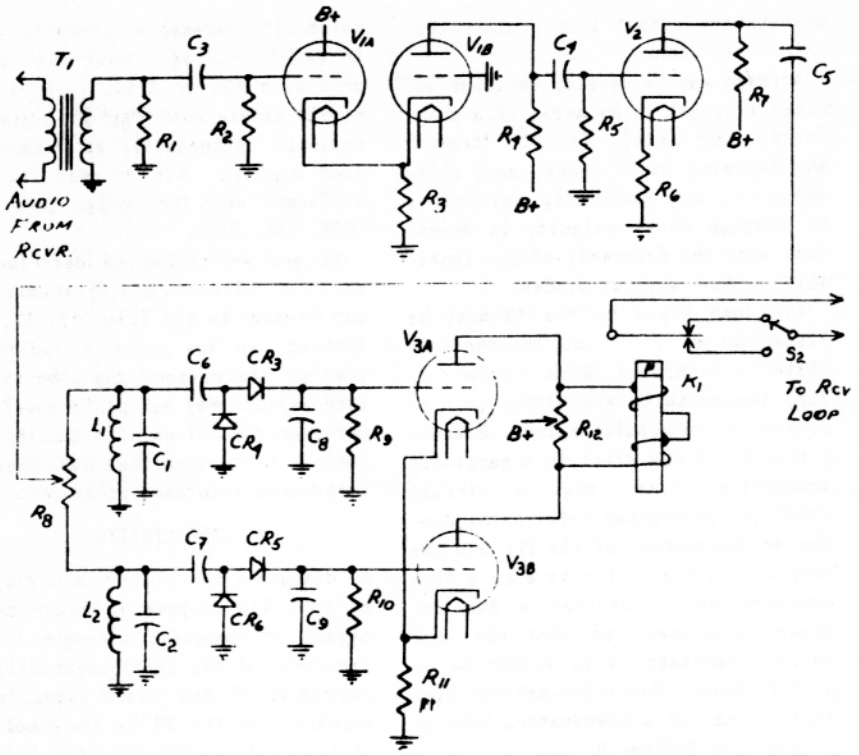
1) The input "Amplifier" and isolation is obtained by means of transformer T1. The AFSK signal obtained from the loudspeaker terminals of the receiver is relatively weak. By running it thru a transformer the signal voltage can be increased many times. Also, the input transformer provides isolation thus preventing possible introduction of noise due to "Ground loops".

2) The purpose of the limiter is to provide to the rest of the unit, especially the DC amplifiers, a signal relatively independent of the strength of the tones coming from the receiver.

3) The amplifier composed of V2 and its associated components is needed to increase the constant but relatively weak signal coming from the limiter to a magnitude large enough to insure that the DC amplifiers have adequate signal. The output from the amplifier V2 consists of the same audio tones that came from the receiver output; the processing of the signal to this point simply amplifies the tones to a constant level.

4) The signal from the amplifier is delivered to the Space and Mark filters thru R8. R8 serves the purposes of effectively isolating the filters from each other, and because it is variable, permits compensation for differences within the two filters. The Space filter composed of L1 and C1 is a simple parallel resonant circuit tuned to the Space frequency of 2295 Hz. At resonance it has a relatively high impedance, but off resonance the impedance is relatively low. If a constant-amplitude, variable-frequency signal is fed from V2 to the L1-C1 filter, the voltage across the filter will be maximum at its resonant frequency and smaller at other freqencies. For example, when a 2295 Hz. tone is fed from the plate of V2, the audio voltage across L1-C1 may be about 10 V, but when a 2125 Hz voltage of the same value is fed from the plate of V2 only about 1/2 volt will appear across L1-C1. This is similar to the action of any tuned circuit. The Mark filter composed of L2-C2 acts in exactly the same manner except its voltage is maximum when a 2125 Hz tone is present and quite small when a 2295 Hz. tone is present.

Before continuing, we will summarize operation up to the filter outputs. The audio signals from the receiver are amplified, then limited, then amplified again. Therefore, regardless of the frequency of the tone the voltage appearing at the plate of V2 is the same. The signal from the plate of V2 is split by means of



R8 and is applied simultaneously to the two tuned circuits composed of L1-C1 and L2-C2. L1-C1 is tuned to the Space frequency, 2295 Hz., and, L2-C2 is tuned to the Mark frequency, 2125 Hz. Therefore, when a Space tone is received the voltage across L1-C1 is relatively large (10 V) and the voltage across L2-C2 is relatively small (1/2 V). When a Mark tone is received, the voltage across L1-C1 is relatively small (1/2 V) and the voltage across L2-C2 is relatively large (10V). Because of its similarities within the circuit, the voltages may not be exactly as stated. This can be partially compensated by adjusting R8.

5) The space voltage doubler rectifier circuit (C6, CR3, CR4, C8) converts the audio frequency voltage appearing across the Space filter into a positive DC voltage which is approximately proportional to the audio voltage appearing across the Space filter.

6) The Mark voltage doubler rectifier rectifies the audio voltage appearing across the Mark filter and delivers a positive DC voltage approximately proportional to the audio voltage appearing across the Mark tuned circuit.

7) One portion of the DC amplifier (V3A) amplifies the positive DC voltage appearing from the Space voltage doubler rectifier and the other half (V3B) amplifiers the DC voltage from the Mark voltage doubler rectifier. The common cathode resistor R11 serves the purpose of making one of the DC amplifiers discriminate against the other one. For example, when a Space tone is received, the voltage appearing on the grid of V3A may be about 20 volts and the voltage appearing on the grid of V3B may be only $\frac{1}{2}$ volt. (These are voltages measured to ground). Because the grid on the V3A is being driven rather hard, the plate current on V3A will increase significantly and this will increase the voltage across R11 making both cathodes more positive with respect to ground than they were with no signal. The Space tone resulted in about 1/2 V appearing from the Mark circuit on the grid of the Mark triode (V3B). However, the cathode voltage on V3B has increased thereby cancelling the effect of the small Space voltage appearing on the Mark grid. When a Mark tone is received, the Mark triode V3B receives the larger voltage and it (V3B) discriminates against V3A. The net result is that the plate current in the triode receiving the signal will be about 10 mA and the plate current in the other triode will be about zero mA.

8) The combination of R12 and K1 translate the varying plate current from the two halves of V3 into loop openings and closures. K1 is a polarized (polar) relay such as the 255-A. When current flows thru the windings in one direction, the armature operates in one direction and when current flows thru the windings in the other direction the armature moves in the opposite direction. For example, when a Space tone is received, current flows from B positive thru the top half of the R12 into the plate of V3A and from B positive thru the bottom half of R12, up thru the relay windings, and into the plate of V3A. This operates the armature in one direction. When a Mark is received, the current flows from B positive down thru the bottom half of R12 and into the plate of V3B; it also flows from B positive up thru the tophalf of R12, down thru the windings of K1, and into the plate of V3A. Because the current is now flowing down thru K1, the armature moves in the opposite direction closing the opposite contact. The armature of K1 and only one contact are inserted into the local loop. Therefore, when the armature of K1 is operated in one direction the loop is closed, and when operated in the other direction the loop is open. By operating switch S1, either relay contact can be used to close the loop. This permits interchanging Mark and Space in case the signal being received is "upside-down".

SOLID STATE TUs

An inconsistency exists, we said that the diodes used to rectify the outputs from the tone filters were reversed in one of the circuits; thus a positive voltage was present when a Mark tone was received and a nega-

ative voltage was generated when a Space tone was received. In the circuit discussed, both tuned circuits fed diodes which were connected to give positive output voltages. Why the apparent discrepancy?

The answer goes something like this: It is desired to have the loop closed when a Mark is received and to have it open when a Space is received. When a polar relay is used, its direction of operation is sensitive to the direction of the current thru its windings. Therefore, if a positive voltage (or current) is applied to one end of the coil, the relay will close its contacts. If a positive voltage (or current) is applied to the other end of the relay coil, it will open its contacts. In the circuit described as the Twin City TU, the positive voltage from the Mark circuit is applied (after amplification by V3A) to one end of the relay coil. The positive voltage from the Space circuit (after amplication thru V3B) is applied to the other end of the relay coil. Thus the Mark and Space signals are effectively subtracted within the polar relay. (Some subtraction occurs in the common cathode circuit of V3, but the bulk of it is done in the relay).

If an NPN transistor is used to key the output loop, it requires a positive voltage to turn it on and a negative voltage to turn it off. Therefore, the signal applied to the base of the transistor must be alternating plus and minus. This can be accomplished by simply taking the DC outputs from the Mark and Space tuned circuits and subtracting them. The subtraction can be most easily accomplished by reversing the diodes connected to one of the tuned circuits, and then simply adding the DC signals. (Adding numbers of opposite sign is the same as subtracting two numbers of the same sign.)

Because silicon transistors will turn off with no bias, the Mark signal alone could be used to operate the loop keying transistor. However, the transistor operation is better if it is purposely turned off, and, especially if noise or fading are present, it is better to use the difference between Mark and Space to operate the output loop, rather than either one alone.

A third way to develop the plus and minus voltages is by means of a phase locked loop (PLL). The PLL "tracks" the incoming audio tones, and, while doing so, it internally develops a DC voltage whose polarity is dependent upon the frequency of the tones- this is done without diodes.

The loop keyed by the TU must be either on or off - no intermediate state is permitted. With a polar relay, the contacts are either open or closed, so no problem exists. However a transistor can exist in a partially conducting state: thus a circuit should be interposed between the diodes or the output of the PLL and the loop keying transistor to make a firm decision as to whether a Mark or Space is present so that the loop keying transistor will either be on or off. Such a "decision-making" circuit is called a comparator, Schmitt trigger, or "slicer."

Three TUs are representative of various degrees of complexity. Harry Legler, WØPB, presented the F2 TU in QST, 1973 January 25ff. It contains only one transistor; the "diodes" (bridge rectifiers) are oppositely poled to give the subtracting action. The ST-5 Irv Hoff, W6FFC (found elsewhere in this handbook, under the title of Mainline article), uses oppositely-poled diodes to subtract the Mark-Space signals which are then run thru a "slicer".

Solid-state TU circuits complete with parts values are given at the end of this handbook.

SUMMARY

We have just described the operation of a simple TU and variations required when a transistor is used to key the loop in place of a polar relay. Next we will describe some additional circuitry which is desirable when receiving signals that contain QRN, QRM and QSB.

DESIRABLE COMPLEXITIES

The Twin City TU was described because its basic principals of operation are similar to those of more complex units; i.e., the Twin City TU contains the fundamental or "absolutely" necessary circuits found in any TU. It is a unit that can be used with FSK or AFSK. It is a relatively simple unit that will give excellent performance on reasonably good signals, but is not the best performer when the going gets rough (QRM, QRN, QSB).

We are not going to describe the specific circuit modifications that can be made to the Twin City TU, But, instead, we are going to point out some of the reasons why a basic unit such as this may not perform well under poor conditions. The possible solutions to be described have been incorporated into many other units.

THE LIMITER

We discussed the limiter and indicated that its purpose is to present a signal of constant strength to the remainder of the unit essentially independent of the audio signal being supplied to the TU by the receiver. This is a desirable situation because at some point within the TU a decision must be made as to whether a Mark or Space is being received so that the loop being controlled by the TU can be closed or opened, respectively. The decision-making process is uniform when a signal of uniform strength is presented. The limiter not only presents a uniform strength audio signal independent of "volume control" setting on the receiver, but it also corrects for one tone being louder than the other; this can result from many causes including the frequency response characteristics of the receiver.

So far, the limiter does nothing but good; however, what happens when a noisy signal is being received?

In order to gain some insight into the answer to this question, digress for a moment. Frequency-shift keying, be it carrier frequency shift keying (FSK) or audio frequency shift keying (AFSK) is a form of frequency modulation. The "better" FM receivers normally use two or more limiters before the detector stage. With FM receivers, when two signals are present simultaneously, the louder or stronger of the two signals "captures" the receiver and will almost totally suppress the weaker signal unless the

two signals are very nearly the same strength. If a signal and noise are present simultaneously, they can both be thought of as signals and whichever is stronger will capture the other. The net result is that when working with FM signals (RTTY, voice, or music) the desired signal is either there and of good quality or not there at all. This is because when the signal is stronger than the noise, the limiters tend to suppress the noise;when the noise is stronger, the limiters tend to suppress the signal. (The so-called "noise-free" characteristics of FM have led to two common fallacies: 1) FM is noise free and 2) FM is better than AM. Actually: 1) When an FM signal is strong it swings, and 2) When the going is rough, AM is better than FM.)

Now back to the TU. So long as the noise is less than the signal, the limiters do their job of equalizing levels, and in addition, tend to suppress noise. However, when a signal gets noisy, the limiters tend to suppress the signal in favor of the noise! The obvious solution appears to be that the limiters should be dispensed with. In general,this is not the answer, although it does, upon occasion, have benefits; i.e., "limiterless" or "AM" operation of the TT/L-2.

A large improvement can be gained by reducing the noise before it gets to the limiters. This can be accomplished by using a bandpass filter before the limiters.

The information in a RTTY signal is contained in a small band of frequencies centered around the Mark and Space frequencies. The interfering noise is spread over the whole bandpass of the receiver. (The actual spectrum of noise is dependent upon its source, the type of detector in the receiver, and the audio bandpass of the receiver.) For example, assume a typical "wide-shift" RTTY signal is being received in the presence of "white noise." The RTTY signal as it appears from the receiver will occupy approximately, a bandwidth from 2125 to 2975 Hz (a bit wider because of keying rate and waveshape). The noise will occupy the frequency spectrum from, perhaps, 300 Hz. to 3300 Hz.

If a bandpass filter is placed between the receiver and the TU, and its bandwidth is adjusted to be just wide enough to pass the RTTY signal, the noise getting into the TU will be reduced by a factor of four times! Generally, the improvement is even better because the noise coming from the receiver tends to be very strong at the lower audio frequencies and relatively weak at the higher frequencies where the RTTY tones are located. The limiter is not frequency dependent. Therefore, by eliminating the very strong low frequency noise components a great increase in receiving performance is gained. Incidentally, a major argument in favor of "narrow-shift" has just been made!

LOW PASS FILTER

The signal in the receiving loop is supposed to consist of on and off pulses of 22 millisecond duration, minimum. When noise is present, the loop may open and close erratically at intervals of less than 22 ms; this can "junk" copy. The effect of noise can be reduced by somehow restricting the speed at which the loop can open and close (change from M to S to M). This can be accomplished by placing a low pass filter between the detector (in the TU) and the loop keyer. In the case of the Twin City TU described, it would go somewhere between the outputs of the voltage doubler rectifiers and the polarized relay.

LOOP KEYER

The output loop should be either open or closed (S or M) and nothing in between. When it is opened, the current in the loop should decay rapidly, and when it is closed, the current should build up very rapidly. (Preferably 1 ms or less). This problem will be discussed later.

The Twin City TU contains a polarized relay that keys the output loop. The relay contacts are either open or closed, thus meeting the criterion that no "half-way" state exist. So long as the power supply feeding the loop is at least 130 volts and so long as there are not too many selectors in the loop (2 is enough), the current rise time will be satisfactory. Therefore, the output loop is indeed theoretically very good. However, it does have three drawbacks: 1)The polarized relay is a precision device and must be carefully and accurately adjusted (An I-193C test set will do this), 2) The contacts on the relay may generate noise that is difficult to eliminate, and 3)Some people just hate polar relays (prejudice).

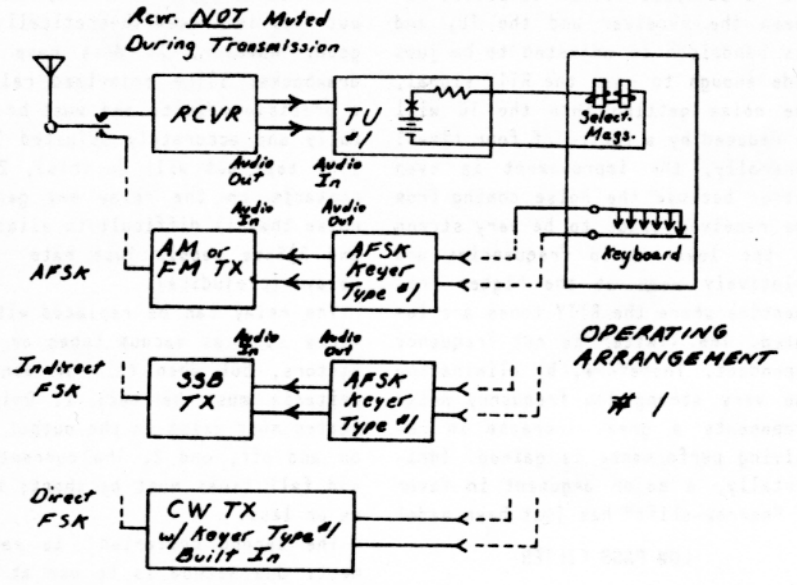
The relay can be replaced with devices such as vacuum tubes or transistors, but when this is done two criteria must be met: 1. Only two states must exist in the output loop, on and off, and 2. The current rise and fall times must be short; i.e.,1 ms or less.

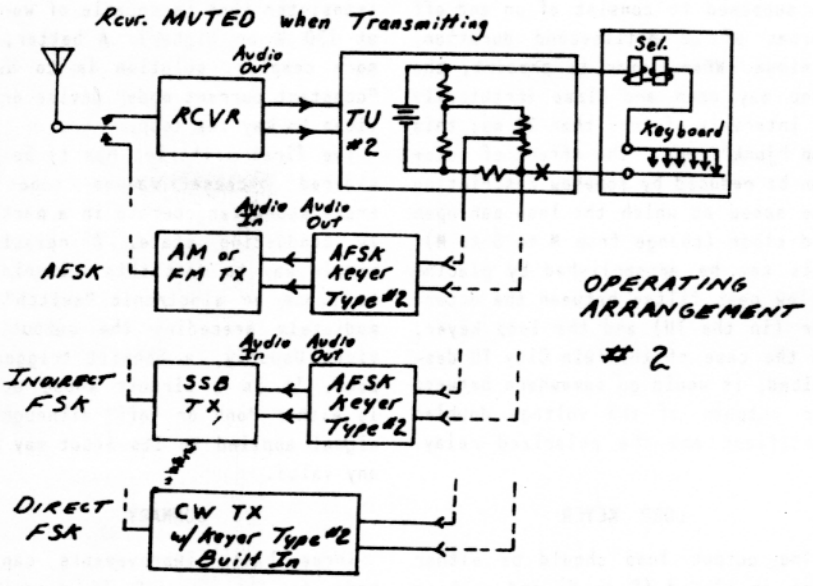
The second criterion is easy to meet. One method is to use at least a 130 volt loop power supply (and a transistor that is capable of working at 130 V or higher). A better, but more complex, solution is to use a "constant current mode" device or devices to key the loop.

The first criterion has to be considered because vacuum tubes or transistors can operate in a partially conducting state. A relatively simple way to meet this criterion is to place an electronic "switch" immediately preceding the output device. Usually, a Schmitt trigger is used. It is a circuit whose output is either "on" or "off" although the signal applied to its input may have any value.

SUMMARY

Three basic improvements can be made to the "basic" TU described. They are, in order of decreasing importance: 1. A bandpass filter placed before the limiter in order to reduce the amount of noise appearing at the limiter. 2. A low pass filter placed after the detector and before the out put keyer; the filter reduces rapid opening and closing of the loop when noise is present, and 3.) An electronic loop keyer to replace the polarized relay; the keyer must include a switch before it and the keyer must have the right time constants.





EQUIPMENT INTER CONNECTION

In order to discuss FSK generation and FSK keyers, it is necessary to give the basic station operating details and the method of interconnection of the various pieces of station gear.

OPERATING ARRAGNEMENTS

There are two basic ways to interconnect the equipment and to operate a station: 1) Connect the output of the receiver to a terminal unit (TU) and connect the output of the TU to the printer. Connect the keyboard to a keyer and connect the output of the keyer to the transmitter. 2) Connect the output of the receiver to the input of the TU and connect the output of the TU to the printer and the keyboard. Connect the keyer input into the loop containing the keyboard, the TU, and the printer, and connect the keyer output to the transmitter.

In arrangement #1, the message being sent is printed locally by leaving the receiver on and tuning it to the transmitter. This arrangement is ideal when running AFSK on VHF FM because FM receivers are normally not muted while transmitting and the receiver doesn't overload. The "local" copy is obtained "off the air" and thus serves as a good check that something is really being sent. The arrangement might create problems with VHF AM because the receiver might get unhappy with the strong signal. Also, if the transmitter and receiver are on two different frequencies, it requires re-tuning the receiver.

In arrangement #2, the receiver is muted while transmitting. Local copy is obtained directly from the keyboard because the keyboard and printer are in the same loop. The receiver does nothing but receive the other station, so it can be left tuned to the frequency. The major objection to this arrangement is that since copy is from the transmitting loop and not from "off the air", you have no really good check that the transmitted signal is really being transmitted. (We have many times copied ten minutes of steady Mark because someone was making local loop copy, but never connected the local loop into the transmitter!)

RECEIVING EQUIPMENT INTERCONNECTION

Next, let's look at the actual interconnection of the station equipment. For either arrangement #1 or #2, the audio output of the receiver is connected to the input of the TU; this interconnection merely feeds the audio tones coming out of the receiver into the TU. The receiver output can be obtained from the loudspeaker terminals or from a headphone jack. It is nice to have the loudspeaker operating because listening to the tones can signal (to the operator) when something has gone wrong (like QRM). However, the constant audio tones can sometimes make one ready for the "funny farm" after an hour or so of listening (XYLs are especially annoyed by the tones). Also, the loudspeaker tends to act as (like) a microphone and it can pick up enough noise from the printer to "junk" copy.

For either arrangement #1 or #2, the output of the TU is connected into a series loop composed of a 130-volt (or higher) dc power supply, a variable resistor, and the selector magnets. The TU opens and closes the loop. Some TUs built in (TT/L-2, ST-5, ST-6) and others require a separate loop supply (CV-89). Obviously, if the dc loop supply is built into the TU, you merely connect the selector magnets to the TU. For most teleprinters, the selector magnets require 60 mA during a steady Mark. The current can be adjusted by means of a series rheostat (2 to 4K, 25W) or by varying the screen voltage on the output tubes. If arrangement #2 is used, the keyboard contacts are also included in the loop (in series with the printer, TU, and power supply), and the keyer must somehow be connected into the loop. (Units like the TT/L-2, ST-5, and ST-6 have a jack for extracting a voltage for operating the keyer.)

With the arrangements described, it should be possible to copy signals regardless of whether you can or want to transmit. Also, the arrangements are independent of whether you want to receive AFSK or FSK. In either case, the receiver must provide at its output an AFSK signal having the frequencies required by the TU.

TRANSMITTING EQUIPMENT INTERCONNECTION

For transmitting, the options become numerous depending upon whether you want to transmit AFSK, indirect FSK (AFSK into an SSB transmitter), or direct FSK and depending upon whether the keyer is to be operated directly from a keyboard (arrangement #1) or indirectly from a TU(arrangement #2).

Take the latter pair of options first. With arrangement #1, the keyer is operated directly from a keyboard; that is, the keyboard is connected directly to the keyer input and nowhere else. Arrangement #2 requires that the keyer get its input signal from the TU (a terminal or jack must be available within the TU to provide the necessary keying voltage). The input circuit of the keyer (be it AFSK or FSK) is different depending upon whether it was designed for direct operation from a keyboard or indirect operation from a TU.

Assume that you want to transmit AFSK. Connect the output of the keyer to the audio input (microphone input) of the FM or DSB AM transmitter. When something is "typed" on the keyboard, the keyer output will contain an audio signal with a warbling (tweedling), characteristic. When nothing is being "typed", a steady audio tone should appear at the keyer output.

If indirect FSK is to be transmitted, connect the audio output of an AFSK keyer to the microphone input of a single sideband transmitter. You must be careful to make sure that the SSB transmitter has adequate carrier and unwanted sideband suppression. The keyer must not overdrive the SSB transmitter. The keyer must have an audio output free-harmonics. Don't burn up the transmitter (or its power supply); you are running constant audio into the transmitter.

If indirect FSK is to be obtained by applying AFSK to an SSB transceiver, the comments applying to an SSB transmitter also apply. Only arrangement #2 can be used. In addition, a frequency offset might give troubles.

*****

"True Transceive" FSK operating with the SB102 (and other SSB rigs)

Ken Ridout, WB5FHF
1521 Cranford
GARLAND, TX. 75401

The main problem in using FSK with a sideband transceiver is that you cannot vary the transmitting frequency without also varying the receiving frequency. Whenever you retune the transceiver to obtain proper mark and space tones for reception, you are also moving the transmitting frequency. The station that you are in QSO with has to retune his rig in order to receive your transmission. This has been called "Leap-Frogging".

The solution to this problem is to vary the transceivers output frequency while leaving the receiver portion stationary. A person can use one of the AFSK units and do slight modification to his rig to allow these standard tones to pass. There is a simpler way to do this without any modifications to the rig.

My rig is the Heathkit "SB102". The LMO(VFO) of this rig has one terminal on it, that, when grounded gives a shift of approximately 1000 Hz. The amount of the shift may be varied by adding resistance between terminal and ground. I use a mercury wetted relay to key this connection. The coil of the relay is connected to the common and normally open contacts of the keyboard, and voltage is supplied by a six volt battery.

Now all you need is a carrier to shift. To get this carrier I use a small audio generator (model TS 382). Connect the audio generator output through a small matching transformer to the mike jack of the transceiver. By varying the audio input frequency, the transceiver's output carrier frequency is varied.

By using another receiver, you can tune in a station on it and the transceiver, key the transceiver in upper side band into a dummy load, and adjust the frequency of the audio generator until your rig matches the other stations mark tone.

After initial adjustment of the audio oscillator, whenever you tune in a FSK signal with the transceiver, your transmitted signal will match the other stations frequency. The result is true transceive operation.

To transmit, I move the function switch from P.T.T. to Vox. Then the audio tone keys the rig.

To get FSK operation, key the SB-102 L.M.O. as described. With other transceivers, you can use one of the applicable VFO keying circuits.

*****

If direct FSK is to be employed, an FSK keyer must be built into the transmitter. (Some come with the keyer built in.) The FSK keyer is connected to the oscillator circuit in

the transmitter or VFO. Two different (although similar) circuits are used depending upon whether the keyer is to be operated directly by the keyboard (arrangement #1) or indirectly from the keyboard via the TU(arrangement #2).

SUMMARY

There are two basic ways to operate a RTTY station. Arrangement #1 makes local copy by actually copying the signal transmitted. The receiver is not muted while transmitting. The receiver is connected to the TU which is connected to the printer. The teleprinter is "split". The keyboard is connected to the keyer which is connected to the transmitter.Arrangement #2 makes local copy by copying directly from the keyboard. The receiver is muted during transmission. The receiver is connected to the TU. The keyboard, printer, and keyer are connected to the TU output. The keyer is connected to the transmitter. The input circuit of the keyer (and to some extent, the keyer itself) is different depending upon whether arrangement #1 of #2 is to be used. For AFSK, an external AFSK keyer is used with an FM or DSB AM transmitter. For indirect FSK an external AFSK keyer is used with an SSB transmitter. For direct FSK, an FSK keyer is built into the transmitter.

GENERATING AN FSK SIGNAL

We have described the basic equipment interconnection necessary for transmitting a RTTY signal. Now, we will go into the details of how an FSK signal is generated.

There are two ways to generate an FSK signal:

A) Indirect FSK is obtained by applying an AFSK signal to the audio input of an SSB transmitter.

B) Direct FSK is generated by modifying the oscillator circuit of a transmitter or VFO so that its frequency can be shifted by the signal from a keyboard.

A. Indirect FSK

An AFSK signal consists of one of two audio tones; e.g. a 2125 Hz tone exists when a Mark is sent and a 2295 Hz tone exists when a Space tone is sent. If the Mark tone (2125 Hz) were applied to a DSB AM transmitter, the output from the transmitter would consist of three frequencies, the carrier, the carrier plus 2125 Hz (the upper side frequency), and the carrier minus 2125 Hz (the lower side frequency). If the Space tone (2295 Hz) were applied to the transmitter audio input, the output would consist of the carrier, the carrier plus 2295 Hz (the upper side frequency), and the carrier minus 2295 Hz (the lower side frequency). If the tones were applied alternately (a Teletype signal), the transmitter output would contain the carrier, an upper sideband (carrier plus 2125 Hz and carrier plus 2295 Hz.),and a lower sidesideband (carrier minus 2125 Hz and carrier minus 2295 Hz). If the carrier and the upper sideband were somehow deleted (LSB,SSB), the only signal left would be two frequencies - the carrier minus 2125 Hz and the carrier minus 2295 Hz - this is an FSK signal (including the proper "sense").

B. Direct FSK

The output from a CW transmitter consists of a single frequency. The output frequency can be shifted downward by applying a small capacitance (3 pF) across the tuned circuit in the oscillator (usually from the oscillator tube cathode to ground). If the small capacitor can be connected and disconnected according to the Spaces and Marks, respectively, in a RTTY signal, then an FSK signal is generated. The most difficult problem with direct FSK generation is the requirement to shift a small capacitance in and out of a radio frequency circuit. Although it would appear that the small capacitor could be simply placed in series with the keyboard contacts and the combination placed from cathode to ground in the oscillator circuit, this arrangement would not work because the capacitance associated with the keyboard contacts and the leads from the keyboard to the oscillator would contain far too much capacitance. Also, the RF in the leads to the keyboard would cause problems. In addition, the keying would be "upside down" because the capacitor is to be added when the contacts are open (Space).

Therefore, the capacitor must be switched by "remote control", as it were. The actual circuit used depends upon whether 1) The FSK signal is to be actuated directly from a keyboard or 2) From a voltage developed in a loop associated with a TU. (Preceeding this, these were referred to as arrangements #1 and #2,respectively.)

DIRECT FSK FROM A KEYBOARD

In Figure 1 is shown the circuit to be added inside the VFO or the transmitter. The basic theory of operation is that when the diode is not conducting (Mark), the entire circuit is assumed to not be present and the oscillator operates at its nominal frequency. When the diode is conducting (Space), the series combination of C1 and C2 is placed across the oscillator circuit and the frequency of oscillation is shifted downward. The radio frequency chokes (RFC1 and RFC2) isolate the diode DC biasing network from the diode and its capacitors (C1 and C2).

When the keyboard contacts are closed (Mark), the top end of the diode is DC grounded and the lower end of the diode has approximately plus 8 volts on it due to the dividing action of R2 and R3. Therefore, the diode is reverse biased and does not conduct,thus effectively removing the capacitors (C1 and C2) from the circuit.

When the keyboard contacts are open (Space), plus 105 volts DC is applied to the upper end of the diode via R1 and plus 8 volts is applied to the lower end of the diode due to the dividing action of R2 and R3. Thus the diode conducts and effectively connects C1 and C2 to the oscillator, lowering its frequency. The amount of shift is determined by the setting

of C2.

There are several notes of caution that should be observed with the direct FSK circuit just described; these cautions also apply to the circuit to be described later. The circuit contains radio frequency energy. Therefore, the actual parts and their placement are important. C1 and C2, and the diode should be mounted as close to the oscillator cathode as possible. Both RFC1 and RFC2 must have low internal capacitance and low capacitance to surrounding objects. RFC2 shunts C2, and if the capacitance from RFC2 is too high it will result in a shift that is too wide and C2 will become ineffective. The resistors should be mounted away from the diode and C1 and C2. RFC1 and RFC2 are to be physically located between the two portions of the circuit and as far from the chassis and chassis bottom plate as possible. The bypass capacitor, C3, is used to keep the oscillator RF out of the keyboard and any RF from the transmitter output from getting back into the VFO via the keyboard leads. C3 should be mounted at the point where the lead from the keyboard enters the VFO/transmitter chassis/cabinet. For example, if a jack is mounted on the chassis (to permit disconnecting the keyboard from the VFO/transmitter), the 0.001 UF bypass (C3) should be mounted on the jack. Also, there should be nothing within the teleprinter connected across the keyboard contacts; all filters, capacitors, etc., must be removed. The only thing connected across the keyboard contacts is to be C3, and that is to be located as indicated above.

DIRECT FSK FROM A TU

In terminal units such as the TT/L-2, ST-5, and ST-6, a keying voltage is provided. (Remember that we are now talking about arrangement #2 where the printer and keyboard are in the same loop along with the TU and the loop power supply. Local copy is made directly from that loop. The received is disabled during transmission.) Within the TU's a circuit is provided that samples the loop current; when a Space is present, a positive voltage of about 40 volts appears on the FSK terminal; when a Mark is present, a negative voltage of about 40 volts is present. (The method for obtaining the voltage will be given later.

Figure 2 shows a typical direct FSK circuit for use with a TU providing a keying voltage. When the TU loop is in Mark, the voltage applied to the keyer is minus 40 volts, the diode is reversed biased, and C2 is disconnected from the oscillator cathode circuit, thus giving the normal carrier frequency. When the TU loop is in Space, the voltage applied to the keyer is plus 40 volts, the diode conducts, thus connecting the capacitor C2 across the oscillator circuit and lowering the frequency.

The comments made previously about care in mounting the components within the VFO/transmitter apply equally well to the circuit in Figure 2. Make sure that C3 is across the lead coming from the TU at the point where the lead enters the VFO/transmitter chassis. (Note: an inverting circuit must also be used with the circuit in figure 2 to give normal space high, mark low operation).

ADDITIONAL DIRECT FSK NOTES

In both circuits given, the amount of shift is dependent upon the capacitance switched in and out by the diode. Some capacitance is added just simply by adding the components. Therefore, if the VFO was precisely calibrated before the FSK circuit was added, its calibration will now be off. The width of the shift is dependent upon the capacitors added as well as by the strays added. The shift can be varied by varying the variable capacitor, C2. If only one shift is to be used and only on one band, C2 can be set once and forgotten. If variable shift is desired, C2 will have to be changed.

If the VFO is followed by a multiplier on some bands, the shift will change with the multiplication. This will necessitate readjusting C2.

If many different shifts are desired or required, they can be obtained by placing a potentiometer in the shifting circuit to control the amount of dc in the diode during Space, thus controlling the conductivity of the diode. The diode does not fully conduct when a Space is sent, the amount of capacitance switched in is not the full amount available and thus the frequency shift is less than the maximum amount. Also, by using a rotary switch, and several pots, each pot can be set for the desired amount of

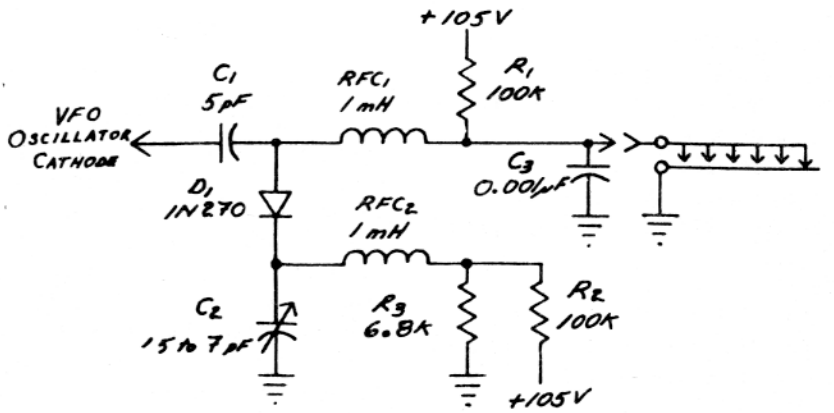


FIG. 1

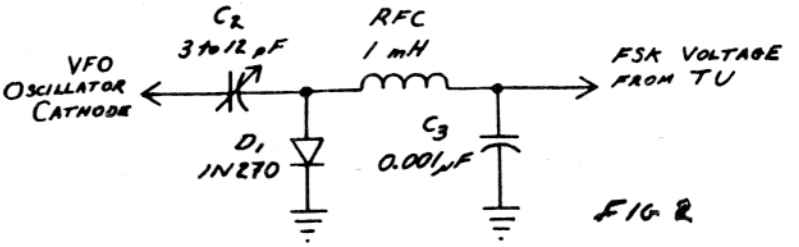


FIG 2

shift for a given band, etc., and just the switch is operated to select the shift desired.

The circuits given in Figures 1 and 2 turn the diode fully on and off - a method that appears to be much less critical of diode characteristics and temperature than does the partially-conducting shift pot method.

Because the FSK circuit (Figures 1 or 2) is to be added inside a transmitter/VFO, the components might not be the exact values required. The following bibliography lists information appearing in the RTTY Journal for specific transmitters.

Transmitter FSK Information Appearing in the RTTY Journal from 1946 thru 1974:

Central Electronics 100V, 200V: 1968 FEB p. 3-5, 1968 MAR p. 2, 1969 JAN p. 14.
Collins 32V: 1964 SEP p. 10-11, 1966 JUN p. 2-8, 1969 MAY p. 5-6.
KWM-2: 1967 OCT p. 3-7.
KWS-1: 1972 FEB p. 13.
S line/KWM-2: 1965 JUN p. 8.
32-S1 & KWM-2: 1965 AUG p. 6-7, 1965 DEC p. 13.
Drake T4X: 1968 MAY p. 3, 1970 OCT p. 2, 4B, 1970 DEC p. 9, 1971 APR p.9
Hallicrafters HT32A: 1965 FEB p. 8-10, 1966 JAN p. 12-13, JUN p. 2-8.
HT 44: 1966 FEB p. 2-3.
Heath DX-60A: 1968 NOV p. 7 (reprint 1972 NOV p. 9, 16), 1971 MAY p. 13-14 DX 60 B
HW-16: 1967 DEC p. 2-3.
Marauder: 1970 JUN p. 13-14.
SB series: 1972 OCT p. 2-3, 1973 DEC p. 17.
SB-101: 1972 OCT p. 4-5.
SB-200, SB 102: 1966 APR p. 8.
SB-400: 1964 DEC p. 12-13, 1965 MAY p. 13, 1966 JUN p. 2-8.
SB-401: 1970 FEB p. 7, 14.
Johnson Invader 200: 1972 APR p. 15-16.
Ranger, Navigator, Valiant: 1968 JAN p. 4-7. Kenwood
Military ART-13: 1965 JUN p. 4-6.
BC-221 Q: 1966 JUN p. 3.
Swan 240 - 350: 1966 APR p. 7, 1968 OCT p. 18, 1969 JAN p. 4, 1971 MAR pp. 2, 13.
General Information: 1964 NOV p. 7, 1965 FEB p. 8-10, 1965 OCT p. 8-11, 1967 FEB p. 3-4, 1967 SEP p. 12, 1967 DEC p. 4-7, 14, 16, 1968 FEB p. 6-7, 20, 1968 APR p. 13, MAY p. 13-14.
Central Electronics 100V & 200V: 1973 JUL-AUG p. 7.
Drake 4B: 1974 NOV p. 20.
Heath DX60B: 1973 SEP p. 3-5.
Heath SB-102: 1973 MAR p. 12, 1973 APR p. 10, 1973 SEP p. 6, 1973 DEC p. 17.
Kenwood R-599: 1973 SEP p. 7, 13, 1974 MAR p. 5-6.
TS-900: 1974 NOV p. 15.

LOOP SUPPLIES AND KEYING VOLTAGES

In the last two parts we have been discussing methods of keying a transmitter. In what was called arrangement #2, it was necessary to obtain from a loop the voltages used to operate the keyer (FSK or AFSK). Now, we will discuss the circuit used in such units as the TT/L-2, ST-5, and ST-6 to obtain (or provide) the necessary keying voltages. We will also discuss loop power supplies in general in order to define the requirements for a loop supply and we will give a typical circuit for a loop supply.

LOOP SUPPLIES

The basic requirement for a loop supply is 130 to 260 volts dc. It must be capable of continuously supplying that voltage at 60 mA. There is no real upper or lower limit to the supply voltage. Below 130 V, time constants in the loop might become troublesome. Above 260 V, the voltages start becoming rather hazardous. (Even 130 volts can be lethal, but the danger increases as the voltage increases.) "Real" telegraph loops usually work at 260 volts.

The reason that the voltage, per se, is not too important is that the loop is made to operate at a specific current, usually 60mA. Therefore, once the supply is built and operating, you place resistance in series with the loop to set the current at the desired level. The higher the voltage, the higher the resistance required and the more power "wasted" in the series resistance. However, because of time constant problems, the more power wasted in the resistance, the better the loop characteristics!

If you have more than one loop, you can use two different approaches to supplying them.

1) Build a separate power supply for each loop, or 2) Build one supply that is large enough to handle all loops at once. The advantage to several "small" loop supplies is that they can be "floated" (isolated or not grounded) and this can be used to advantage for keying other loops, etc. (to be described later). The approach used here was to build one big supply (130 V, 1 A), ground the negative terminal, and run whatever is desired from it.

If you intend to build a TU such as the ST-5 or ST-6, you can buy the power supply components for it now and build a loop supply. Later, you can cannibalize it and reuse the parts in the complete TU. This is a very economical approach. See: "Mainline ST-5" article by Irvin Hoff, W6FFC.

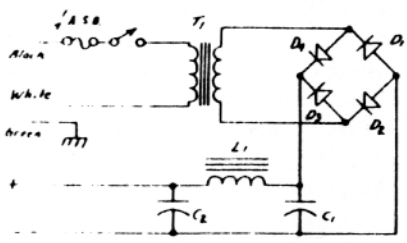


Fig. 1

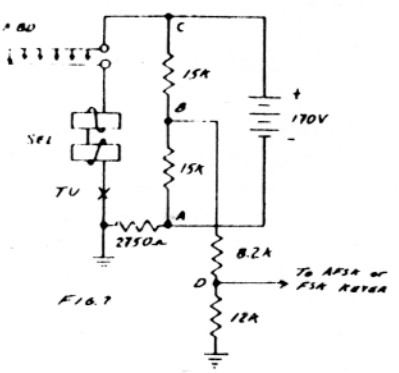


Fig. 2

If you want to build one from scratch, you might try the circuit shown in Figure 1. Basically, it is a simple full-wave bridge rectified supply with capacitor input filtering. The transformer is a simple "isolation" transformer. The advantage of using an isolation transformer is that it can always be used for its original purpose if you no longer want it for a loop supply. Suitable type numbers are: Allied 6K112HF, 6K38VCP; Essex (Stancor) P-6410; TriadN-51X, N-68X. These are all 35 or 50 VA transformers. Many are available in higher power (VA) ratings.

For the rectifiers, the old standby 1N4005 is an excellent choice. If you want a bridge assembly (all four diodes in one blob), try the Motorola HEP177 (280 Vrms, 1A), Mallory FW-600 (600 PRV, 2A), or the International Rectifier 18DB4A (282 Vrms, 1.8A).

If you use one of the transformers listed (or a higher VA rating transformer), you should use capacitor-input filtering as shown. For the input capacitor, C1, try 20 uF or higher at 200 or 250 Vdc. The capacitor size will control the output voltage. For the output filter, C2, use something in the 300 uF range, or higher. We have used the Mallory HC20005 (500 uF, 200 V). The Sprague 142F200BC (1400 uF, 200 V) will work nicely.

For L1, a 2H choke rated at 60 mA or higher should be used. The Allied 6X19HF, Essex (Stancor) C2325, or the Triad C-21X should be adequate; they are rated at 200 mA dc or higher.

You can try using an old TV set power transformer. Unfortunately,they are usually rated at voltages a little higher than really desired. By using one in a conventional full-wave, centertapped circuit with a choke input filter, it might be possible to get the voltage low enough to be suitable. If you use a choke-input filter, make sure that there is a load across the output at all times (a bleeder) because the output voltage tends to get quite high under no load. A simple wire wound resistor drawing 10 to 20 mA should be suitable.

KEYING VOLTAGE FROM A LOOP

In the two previous installments of this series we described two different operating philosophies or equipment arrangements. In arrangement #2, the output of the TU was placed in a loop containing the keyboard, the selector magnets, the loop supply, and a current limiting or adjusting resistor.When transmitting, the receiver is muted. When "typing" on the keyboard, the printer gives copy "direct" from the keyboard. The keyer (FSK or AFSK) is operated from this loop.

The means of obtaining the keying voltage from the loop is shown in Figure 2. A 170 volt dc power supply is connected in series with the keyboard, the selector magnets, the output device in the TU (indicated by an X), and a current limiting resistor (2750 ohms). When the loop is closed (Mark), point C is nearly at ground potential and point A is at about - 170 volts. The midpoint of the two 15K resistors, point B, is at about - 60 volts, and point D is at about - 40 volts. When the loop is opened (Space) by either opening the keyboard contacts or by the TU, point A is at nearly ground potential and point C is at about plus 170 volts. Therefore, point B is at plus 60 volts, and point D is at about plus 40 volts.

The - 40 volts at point D during Mark and the plus 40 volts at point D during a Space is supplied to the keyer (for example, in FSK keyer given in Figure 2) and the keyer thus keys according to the Marks and Spaces in the loop.

GEARS AND THINGS

Unlike the code used for hand-keyed telegraphy with its variable-length characters, the Murray code used with amateur printing telegraphy(Teletype) has a fixed-length format; i.e., all characters be they the letter E or the letter Y, are of the same length. This fixed-length format is related to operating speeds within the machines.

Teleprinters, when arranged to communicate with each other, are connected in a series circuit called a loop. That is, the keyboard contacts and the selector magnets are in series. Power is supplied to this series circuit by means of a dc power supply of at least 130 volts. A resistor is inserted into the loop to limit the current to 60 mA.

A character is sent by depressing a key on the keyboard. When the key is depressed, contacts within the machine open and close in a predetermined pattern at a fixed rate.

The actual character is composed of five time intervals during which the circuit is either open or closed. The condition when no current is flowing (contacts open) is referred to as a Space (S). When current is flowing, it is called a Mark (M). Each M or S is approximately 22 milliseconds (ms) long. Each character is preceded by a Space, called the Start pulse. Each character is followed by a Mark, called the Stop pulse.

With Bell System machines running at so called "60 Speed", the Stop pulse is 31 ms long. The Start pulse and the five character elements are 22 ms long. Therefore, it takes 163 ms for every character. A "word" is defined as 5 characters and a character space. Therefore, it takes 6 times 163 ms or 978 ms(0.978 seconds) for one word. The number of words per minute is 60 (1 minute equals 60 seconds) divided by 0.978 which equals approximately 61.3 words per minute (WPM). Therefore, a Bell System teleprinter operating at its maximum speed will print 61.3 words per minute; this is called "60 Speed" operation.

With Western Union machines, the code is the same as for Bell System machines (the only difference being that the apostrophe and bell are interchanged). However, the Stop pulse is only 22 ms long with a Western Union machine (vs. 31 ms with a Bell System machine). Therefore, a W.U. machine character takes 7 times 22 ms equals 154 ms. A word takes 6 times 154 ms equals 924 ms or 0.924 seconds. Dividing 60 (seconds per minute) by 0.924 gives 65

words per minute.

In spite of the different operating speeds in words per minute, the two machines are perfectly compatible.

The mext item to consider is the speed at which various things within a teleprinter operate.

In the U.S., commercial ac power is generated at exactly 60 Hz. Therefore, an 1800 RPM synchronous motor will operate at exactly 1800 RPM. Ditto for a 3600 RPM synchronous motor.

Because the transmitting shaft (the keyboard shaft), the receiving shaft (the selector shaft), and the motor are geared, they must always revolve at constant relative speeds. So long as a synchronous motor is used, they also rotate at constant absolute speeds. Because gears must have an integral (whole) number of teeth, only certain speed ratios are allowed. One revolution on the transmitting (keyboard) shaft corresponds to one character. If you lift the lock loop on the transmitting shaft or depress the repeat key, the machine will continuously transmit a character at machine speed. On a Bell System machine, one character takes approximately 0.163 seconds; therefore, the transmitting shaft should rotate at 1/0.163 revolutions per second or 60/0.163 RPM which equals 368.1 RPM. Assuming that the motor is a synchronous motor operating at 1800 RPM, the gear ratio from the motor to the transmitting shaft must be close to 1800/368.1. The closest integral ratio is 1800/367.5 which is 30/7 times 24/21; 367.5 RPM is 367.5 characters/minute which equals exactly 61.25 WPM. (The reason for a double ratio such as 30/7 times 24/21 will be explained later; it is related to the mechanical power train sequence within a machine.)

On the Western Union machines, the ratio desired is 60/0.154 or 389.61 RPM. The closest gear ratio to 1800/389.61 is 30/7 times 13/12. Therefore, with a motor speed fixed at 1800 RPM exactly, the transmitting shaft will revolve at 387.6923077 RPM which will give a speed of 387.692307 characters/minute or 64.61528 WPM or Mark and Space time intervals of 22.10884 ms.

When receiving a RTTY signal, the receiving shaft operates continuously. However, the "decoding" mechanism on that shaft does not run until the Start pulse is received; the mechanism on the receiving shaft then rotates until the code elements have been received. Because the receiving cam does not have to rotate for the entire character interval, but only during the start pulse and the five intervals that contain the character code, the receiving shaft can run faster than the transmitting shaft.

There is a subtlety involved here. If the two machines are not running at exactly the same speed, then the receiving shafts must run faster than the transmitting shafts. If they did not, the receiving machine that was running slower would fall behind. Machines had to be designed to run at slightly different speeds because when the machines were first designed and built, governor-controlled motors had to be used because either only dc power was commercially available or the commercially available ac power was not frequency stable. (This leads into a long, perhaps, interesting, discussion about electric clocks, synchronous converters, constant voltage transformers, etc.) Also, if machines are operating at exactly the same speeds, and the transmitting and receiving shafts are also operating at the same speeds, and one machine gets out of step with the other, they can never get back into step. However, if the receiving shaft is running faster than the transmitting shaft and stops at the end of each character, then if they get out of step, they can resynchronize within a few characters.

Anyway, the receiving shaft has to run faster than the transmitting shaft. The receiving shafts in both Western Union and Bell System machines run at exactly 420 RPM. With an 1800 RPM synchronous motor, a gear (actually a pinion-gear combination) ratio of 30/7 will give exactly 420 RPM from 1800 RPM. Not only do W.U. and Bell machine receiving shafts run at the same speeds, but the selector mechanisms are identical. Hence, the machines are perfectly compatible because their selectors are identical!

One further note on the gear ratios. Within a TTY machine such as the Model 14 and 15, the motor drives the receiving shaft. For "60 speed" (61.25 WPM, Bell; 65 WPM, W.U.), the receiving shaft must run at 420 RPM. Therefore a gear ratio of 30/7 is always used between an 1800 RPM synchronous motor and the selector shaft. The transmitting shaft is run from the receiving shaft. (A jack shaft may be used between the receiving shaft and transmitting shaft.) The gear ratio between the receiving shaft and the transmitting shaft is fixed dependent upon whether the transmitting shaft has a 7-unit cam for W.U. format or a 7.42 unit cam for Bell format. The ratio is 39/36 on a W.U. machine and 24/21 on a Bell machine. With a Model 28 for Bell System operation, the 3600 RPM motor has a 14-tooth pinion driving a 96-tooth gear on a jack shaft. The jack shaft has a 48-tooth gear which drives a 60-tooth gear on the selector shaft. This combination gives a 60/7 ratio which results in a selector shaft speed of exactly 420 RPM from the 3600 RPM motor. The selector to keyboard shaft gear ratio is the same 24/21 as on Bell System Model 14 and 15.

Because the gear ratio between the receiving shaft and the transmitting shaft is set according to the cam format on the transmitting shaft, these gears should never be changed. However, if the motor speed or operating speed is to be changed, then the gear ratio between the motor and the receiving shaft is to be changed.

When changing speeds, while still using the Murray code, only the motor or selector shaft speed is to be increased because the transmitting shaft speed will change accordingly. However, a sad fact of life is that essentially no one except amateurs are using the Murray code. Commercial operation is now at 100 or 150 WPM. You cannot speed up your machine to 100 or 150 WPM operation and expect to copy the commercial stations because they use an entirely different code! The trouble with the Murray code is that it contains only 5 code elements and that means only 32 characters are possible without shift-

ing. The commercial users are using the ASCII (American Standard Code for Information Interchange). This code contains 7 code elements, giving 128 characters without shifting (and twice that many with shifting).

The ASCII code and its details can be found in the IT&T Handbook (Reference Data for Radio Engineers, 5th ED., Howard Sams). It is a 7-element code, plus a start pulse, a stop pulse, and a parity pulse. For 100 WPM operation, the stop pulse is two units long, resulting in 11 units per character. The units are 9.09 ms long. The 150 WPM version is the same except the stop pulse is only one unit long, giving a 10 unit character with 6.66 ms long units.

See RTTY, 1969 JUL-AUG p.4 for speed information on the amateur Murray code and p.11 for motor-selector shaft gear information.

We would like to acknowledge the assistance of Clarence Kersker, WA8AYS, and Dave Goodman, WA8UIT, who dug into the innards of machines to count gear teeth.

RTTY TUNING INDICATORS

The following is not meant to be an exhaustive discussion of tuning indicators, but it will give some thoughts about ways to indicate the tuning status when receiving a RTTY signal.

There are at least three ways to indicate tuning of a receiver when trying to copy a RTTY signal: 1) A display on an oscilloscope of the demodulated signal versus time, 2) A cross as viewed on the face of a cathode ray tube, and 3) A zero indicating meter.

Before discussing how to connect a tuning indicator, a brief discussion of TUs is in order. The figure shows the "heart" of most audio-type TUs.

Basically, the operation is as follows. The tones coming from the receiver are run thru a limiter and amplifier. The audio output from the limiter/amplifier is coupled thru the two resistors, R, into two tuned circuits.The resistors are made fairly high in value to preserve the Q of the tuned circuits and to isolate them as much as possible. One of the tuned circuits is tuned to the Mark frequency and the other to the Space frequency.

Because the tuned circuits are parallel resonant, an audio voltage appears across only one tuned circuit at a time, and only when the frequency of the signal is at or near the resonant frequency of that tuned circuit. Thus, when a Mark tone is received an audio voltage will appear across the Mark tuned circuit and none (or very little) across the Space tuned circuit. When a Space tone is received, just the opposite will occur.

The voltage appearing across a tuned circuit is rectified using the same type voltage doubler commonly used in power supplies. The diodes connected to one tuned circuit are reversed from those on the other tuned circuit. In this example, a Mark tone results in a voltage across the upper tuned circuit and this voltage gives a positive dc voltage at point X. A Space tone results in an audio voltage across the Space tuned circuit and this results in a negative dc voltage at point X.

The voltage at point X will be a replica of the signal in the transmitting loop at the sending station and will be in polar form. The voltage at this point is used to key the output loop thru a dc amplifier ("keyer" tube or transistor) in a simple TU, or it can be processed thru various circuits such as a low pass filter, a level decision making stage, etc., before keying the output loop.

1) Perhaps the best tuning indicator from the standpoint of obtaining the maximum amount of information about the signal being received employs an oscilloscope arranged to give the demodulated signal as a function of time. For this you will need a dc coupled capability and a triggered sweep. The signal displayed will, ideally, be that pictured in a handbook showing a RTTY character. You can obtain such a display by connecting the scope input to point X in the figure. At this point, the signal has not been cleaned up by the circuits within the TU that prepare it for keying the output loop. Therefore, all noise and other forms of trouble making voltages will appear on the display. Perhaps the least desirable feature of this method of tuning is that it will provide a lot of information about the signal, and perhaps too much! One of the most interesting features is that it shows all the "crud" generated in the keyboard contacts of the transmitting station.

2) An oscilloscope can be connected to a TU in such a way that a "cross" pattern results when a RTTY signal is received. Adjust the scope for use with an external horizontal input. Connect the frame of the scope to the "ground" or common point on the TU, the vertical input to point "M" in the diagram, and the horizontal input to point "S".

Because the internal sweep is disabled, an ac voltage applied to the vertical input will give a vertical line; an ac voltage connected to the horizontal input will give a horizontal line. Ideally (for the purpose of scope display), the Q of the tuned circuits in the TU should be as high as possible. When a Mark signal is received, a vertical line will appear on the oscilloscope, because an ac voltage will appear across only the Mark tuned circuit. When a Space tone is received, a horizontal line will appear. If the oscilloscope is properly adjusted, the height of the Mark vertical line will equal the length of the Space horizontal line.

When a RTTY signal is received, the scope will show the horizontal and vertical lines alternately, and this will appear as a cross. Once the scope is adjusted to give a proper cross on a properly-tuned signal, you can then use the scope as an aid in tuning a signal.

Several things can cause the pattern on the scope to be other than ideal. The Q of the tuned circuits should be low enough to give proper operation of the TU. This will mean that even when a Space tone that is on frequency is being received, a small voltage will appear across the

Mark tuned circuit. Consequently, the horizontal line will actually appear as an ellipse; ditto for a Mark (vertically-oriented ellipse).

When a signal is being tuned in, size, position, and shape of the ellipses will change. Once you are familiar with such a tuning indicator the pattern will tell you how well tuned the signal is as well as such things as the shift of the signal being received in relation to the shift to which your TU is adjusted, etc.

3) Because the signal at point "X" is a polar signal, a zero-center meter connected from point "X" to ground will read approximately zero when a RTTY signal is received and properly tuned. This is somewhat analogous to the zero-center tuning indicator used on some FM receivers. When a steady Mark or Space is being received, the meter will not read zero. Therefore, this type indicator is best for use when a steady, machine speed (tape) signal is being tuned in. A VTVM adjusted for center zero can be used very satisfactorily in this application. Additional information about tuning indicators can be found in the following references:

RTTY FROM A TO Z, Durward J.Tucker, W5VU, Cowan Publishing Co. (CQ),1970, p.180 (Fig.14.10), pp.194-198.

THE NEW RTTY HANDBOOK, Byron H. Kretzman, W2JTP, Cowan Publishing Co. (CQ), 1962, pp.145-156.

HAM-RTTY, W2NSD/1 & W4RWM, 73 Inc., 1963, p.60, pp.76-77.

It should be noted that there are two types of "cross-indicators". One type is as described above. The other was omitted because it required some (although very little) additional circuitry. Some of the references cited show how to build a complete RTTY tuning indicator that is independent of the TU. If you do not own an oscilloscope, you can build a special oscilloscope just for RTTY tuning indication. Such a scope is included in some of the references cited.

Another somewhat curious note: The three largest, and best-known amateur handbooks were checked for tuning indicator circuits - there were none!

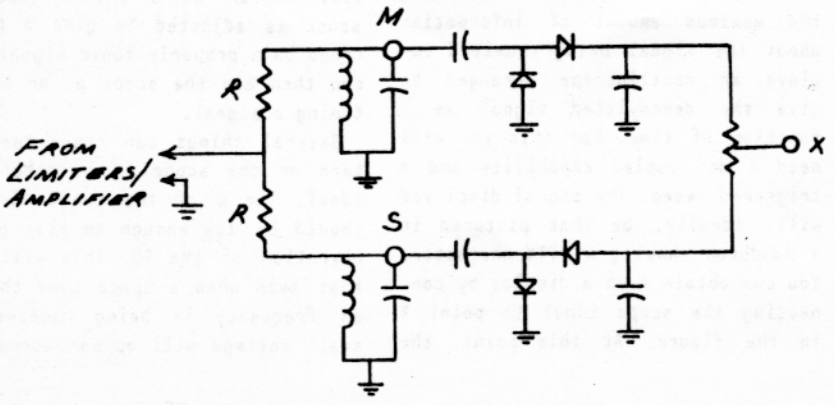
TIME CONSTANTS IN TELEGRAPH LOOPS

The effects of time constants in telephraph loops will be discussed to show how they affect selector operation.

SERIES R, C CIRCUITS

When a series circuit composed of a resistance, R, a capacitance, C, and a DC source, V, are connected, a current I equals V/R flows at the instant of circuit closure. As time progresses, the current slowly decreases until it reaches 0. The decay of current is governed by the product of R and C, and the current decays to 36.8% of its initial value in a period of time in seconds equal to the product of R in ohms and C in farads. The voltage across the resistor follows this same pattern; it starts at V volts at the time of circuit closure, decreases to 0.368V in RC seconds, and ultimately reaches 0 volts. The voltage across the capacitor starts at 0 volts, reaches (1-0.368)V equals 0.632V in RC seconds, and finally reaches V volts.

If, after the capacitor has charged to V volts, the battery is disconnected, the capacitor will remain charged indefinitely. When the circuit is closed with the battery removed, the capacitor will discharge and will reach 0.368V volts in RC seconds.



SERIES R, L CIRCUITS

In the case of a series R, L circuit there are some similarities and some differences from the R, C situation. For example, consider a simple series circuit composed of an inductor, L, a resistor, R, a battery of V volts and a switch. Assume that the circuit is sitting with the switch open; no current flows and the voltage across the resistor and inductor is zero. When the switch is closed, the voltage across the inductor immediately becomes V volts, but the current is still zero and the voltage across the resistor is also zero. The current slowly increases until it ultimately reaches I equal V/R amperes. The increase of current is dependent upon the ratio of L to R. The current reaches 0.632V in a period of time in seconds equal to L/R where L is in henries and R in ohms. The voltage across R follows the same pattern reaching 0.632V in L/R seconds, and the voltage across the inductor decays to 0.368V in the same L/R seconds.

A similarity between R, L and R, C circuits is they both have time constants; a difference is the R, C circuit time constant is proportional to R while the R, L circuit time constant is inversely proportional to R. Another difference becomes evident when the switch is opened. In the R, C circuit, as noted above, the capacitor can remain charged indefinitely; after the switch is opened, the voltage across the capacitor will remain at V volts until something is done to the circuit. In the R, L circuit the inductor can remain "charged" only so long as the current remains at I amperes, and this requires that the circuit remain closed. As soon as the circuit is

opened, the inductor will "discharge". The "discharge" of the inductor, regardless of the circuit configuration, must obey the rule that current thru the inductor cannot change instantaneously. This leads to two interesting situations:

1) Assume that the circuit is as described previously: A simple series combination of an inductor, a resistor, a switch, and a battery. Assume that the switch has been closed for awhile and a steady current is flowing. If the switch is opened, current must cease, but the inductor will not permit it to cease instantaneously. Therefore, as the switch contacts separate, the inductor will react by generating a "back emf" of sufficient magnitude to break down the air gap between the contacts for a sufficient period to allow the discharge of the inductor; the air gap breakdown is evidenced by a spark. This sparking will, of course, eventually damage the contacts. A remedy is to provide some alternate path for the inductor discharge current. A device providing this path is known as a Contact Protection (C.P.) network.

2) Assume the circuit is the same as described previously, but in addition a C.P. network composed of a series R,C circuit is placed across the contacts. (The mathematical analysis of this arrangement can become a bit much unless certain assumptions regarding component sizes are made; we will assume the appropriate values.) Because the C.P. network is across the switch contacts, it will have no effect upon circuit operation when the switch is closed; the closed or mark interval time constant will be L/R, where R is the loop resistance. When the switch is open the total resistance of the circuit will be the sum of the loop resistance; call this total resistance, r. Therefore the open-switch or space interval time constant will be L/r. The spacing or "turn-off" condition resistance, r, is larger than the marking or "turn-on" condition resistance, R; consequently, the current decay at switch opening will be faster than the current build-up at switch closure.

A SELECTOR MAGNET LOOP

Consider the following series circuit: A 260-volt DC power supply, a teleprinter selector magnet, a resistor, and a set of metallic contacts with a C.P. network across them.

The selector magnets have some resistance and an inductance, L. The resistor is set to such a value that its resistance plus the resistance of the selector magnets is 4330 ohms. (This value will permit a steady-state current of 60mA to flow in the selector magnets.) Call the total loop resistance, R. (R equals 4330 ohms.) The metallic contacts can be either the keyboard contacts or the contacts on a polar relay. (We will consider driver tubes and transistors later.)

The magnetic pull exerted upon the armature by the selector magnets varies with the current flowing in the magnets.

When the contacts in the loop are closed the current will slowly build up and the magnetic pull exerted by the selector magnets will also build up. The rate of build up of magnet pull is dependent upon the L/R ratio of the circuit. When the contacts are opened the current will decrease and so will the pull of the selector magnets at a rate dependent upon the L/R ratio of the circuit during the open contact situation. Since the resistance of the circuit is higher during the open interval than during the closed interval, the armature will release faster than it operates; therefore, spacing bias is introduced into the printer mechanism.

The current decay time may be so short compared to the build up time that the decay time can be ignored. If this is true, the amount of spacing bias introduced into the printer is determined solely by the L/R ratio in the selector magnet loop. (It is assumed that the contacts are being operated by an unbiased source.)

Bias can cause troubles when receiving, especially when conditions are less than ideal. The "standard" landline telegraph loops are 260-volt, 4330 ohms, 60 mA and 130-volt, 2170 ohms, 60 mA. Therefore, the manufacturer/designer of teleprinters designed the machines to give best performance when the selector magnets are inserted into these loops.

LOW-VOLTAGE LOOPS

With the advent of transistors, the 130-volt or higher loop was considered a real pain. This is especially true since 130-volt transistors are (or were) expensive(or non-existant). Because the actual voltage across the selector magnets when energized is typically 12 volts or less, there is a temptation to run the selector magnets from a 12-volt source in series with a transistor using non external resistance. Assuming that enough drive is available to the transistor, the selector magnets will get their required 60 mA current (at least under static conditions) and all seems well until trouble is encountered while receiving under difficult conditions.

An examination of the circuit constants will reveal the following: With a 260-volt, 60-mA loop, the circuit time constant is L/4330; with a 130-volt, 60-mA loop, the circuit time constant is L-2170; and with a 12-volt, 60-mA loop, the circuit time constant is L/200. This means the bias introduced by the loop time constant when using a 12-volt source is 11 times greater than with the 130-volt loop and 22 times greater than with the 260-volt loop! No wonder it is sometimes difficult to receive.

With a vacuum-tube magnet driver the situation is inherently better than with the "typical" transistor circuit because a higher voltage loop source is used. A triode or triode-connected beam power tube will give performance equal to metallic contacts for a given supply voltage. A pentode operated in a "constant-current" mode will outperform all other switching devices especially under the most difficult circumstance of several selectors in the same loop.

CONCLUSION

Selectors were made to be operated in loops having at least a 130-volt source. So long as the selector magnets are driven from a source of at

least 130-volt, loop time constants should not be a problem.

We have omitted from the discussion certain details such as selector operate and release currents and protection diodes used with transistor drivers. The topic will be discussed in a more thorough and detailed manner later in the text, and it will include some items not covered.

MORE ABOUT TELEGRAPH LOOPS or THE CARE OF RTTY SIGNALS AND THE FEEDING OF SELECTOR MAGNETS

There is a common misconception about the method of driving the selector magnets in a teleprinter. Time constants and generally how they affect teleprinter operation were described. Now, we will go into the subject in a more detailed manner, describing some of the common loops and showing how each affects selector operation. The conclusion will give some simple rules for loop design or evaluation.

Probably the main reason that selectors are put into unsatisfactory loops is the close resemblance of selectors and ordinary-type relays. A run-of-the-mill relay has a coil voltage rating. Therefore, it is logical to expect that the selector magnets in a teleprinter should also have some voltage rating and so long as that voltage is applied the teleprinter will function properly. ABSOLUTELY NOT!

Selector magnets have a current rating. They should be supplied from a current source, not a voltage source. Unfortunately, a real, live current source is non-existent. However, a current source can be simulated by using a relatively high voltage in series with a resistance. (The higher the voltage source and resistance, the closer will be the simulation.) The following will show how to do this and what happens if it isn't done.

AN INDUCTANCE-FREE LOOP

In order to provide a point of reference, we will consider first a loop containing no energy-storage elements; i.e., no inductance or capacitance. Figure 1(a) shows such an idealized loop composed of some DC source, E, a resistor, R, and a switch, S. The voltage source and the resistor can be any value desired so long as their ratio permits a current, I equals E/R, of 60 mA to flow when the switch is closed. The switch can be metallic contacts, a vacuum tube, or a transistor. (Note that at this point we are not particular about the total loop resistance or supply voltage so long as the loop current is 60 mA. However, it will become apparent later that the source voltage and loop resistance are as important as the loop current.)

The switch is assumed to be driven in such a manner that it opens and closes at even intervals of 22 ms each, corresponding to the element length of a "60-Speed" RTTY signal.

BIAS DISTORTION

Bias distortion, or, as it is usually called, bias, is the measure of the unevenness in length of mark and space elements. Usually it is expressed as a percentage, and can be calculated from the formula: %Bias equals 100(m - M)/M, where m is the actual length of a mark interval in units of time and M is the expected or normal length of a mark interval in the same time units.

For example, in Figure 1(b) the mark interval is supposed to be 22 ms long and it is shown as 22ms long, therefore the percent bias in Figure 1(b) is 100 (22-22)/22 equals 0%.

In all examples to follow, the "ideal" mark will be 22 ms long, therefore in all calculations M equals 22 ms.

RECEIVING DEVICES

In a receiving device such as the selector in a teleprinter, there are essentially two conditions or states that the device can be in, the unoperated or spacing condition and the operated or marking condition. When no current is flowing in the magnets, the armature will be unoperated or spacing. If current is slowly increased, the armature will operate when the current reaches a certain value called the operating current and at that point the armature will mark a space-to-mark (S-M)transition; if the current is increased after the armature has operated, no further action will take place. If the current is slowly decreased, the armature will remain operated until a certain current value is reached, at which point the armature will release and a mark-to-space (M-S) transition will result. Once the armature has released, an additional decrease in current will cause no further action. The value of current at which the armature releases is called the release current.

The operate and release currents are dependent upon the immediate history of current within the device and upon the adjustment of the selector, especially the tension spring, if present, and the operated and non-operated air gap between the armature and the pole pieces of the magnets.

Because of the adjustment and history factors, the operate and release currents may be somewhat nebulous values. The operate current will always be more than the release current and may be several times as great. However, for illustrative purposes we will initially assume the two current values are equal and equal to 30 mA (half the normal loop current).

AN IDEAL SELECTOR IN A SIMPLE LOOP

Assume a selector could be built having no inductance in the magnets and having identical operate and release currents of 30 mA. Place this "ideal" selector in the loop shown in Figure 1(a). Because there is no inductance in the selector, the current would appear as shown in Figure 1(b). The dotted line indicates the "operate-release" currents of this idealized selector. On a S-M transition in current, the selector operates when the current goes thru 30 mA as indicated by point A. On a current M-S transition, the selector releases when the current goes through 30 mA as indicated by point B. (Point C will be considered later.)

Because the distance from point A to point B is 22 ms, the bias introduced into the selector is zero. (In this example m equals 22 ms, the distance from A to B.)

A SEMI-IDEAL SELECTOR

To progress one step toward a practical rather than ideal selector, assume the selector still has the same operate-release current levels of 30 mA, but that it has 4H inductance in the magnets. Insert this magnet into a simple series loop with contact protection as shown in Figure 2(a). Note that the supply is a 130-volt source. R is the total loop resistance including the selector magnet resistance. S is assumed to be metallic contacts.

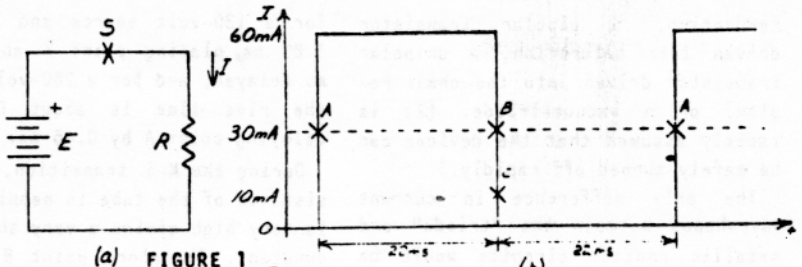
The loop current is shown in Figure 2(b). Because of the magnet inductance, L, it is no longer "square". In the S-M transition, the L/R time constant due to selector magnet inductance shows up and is approximately 1.84 ms. In the M-S transition, there is some overshoot resulting from the contact protection network composed of RCP and CCP. The time for the current to decay from 60 mA to the point where it makes the axis crossing is approximately 0.66 ms.

The operating point, A, is delayed by about 1.28 ms because of the delay in current build-up due to the L/R time constant. Due to the L-R-C "time constant", the release point, B, is delayed by approximately 0.20 ms. Therefore, bias is introduced into the selector as a result of its own magnet inductance. In order to calculate the bias, m must be determined; m equals 22.00 - 1.28 plus 0.20 equals 20.92 ms. Therefore, the bias is 100 (20.92 - 22.0)/22.0 equals -4.9 or 4.9% spacing bias. This is not a bad value.

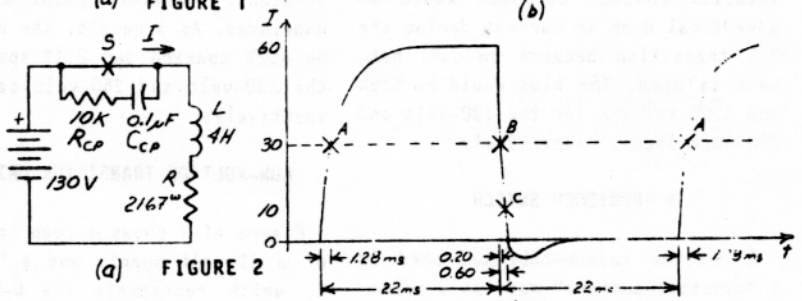
If a 260-volt source were used, R would be 4330 ohms and the bias would be approximately 2.1% spacing.

A "TRIODE" SWITCH

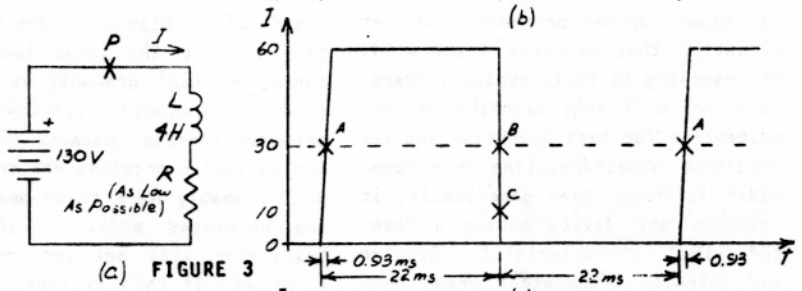
Metallic contacts may be considered archaic. Therefore, replace the contacts with a triode-like device such as a vacuum-pentode driven into hard



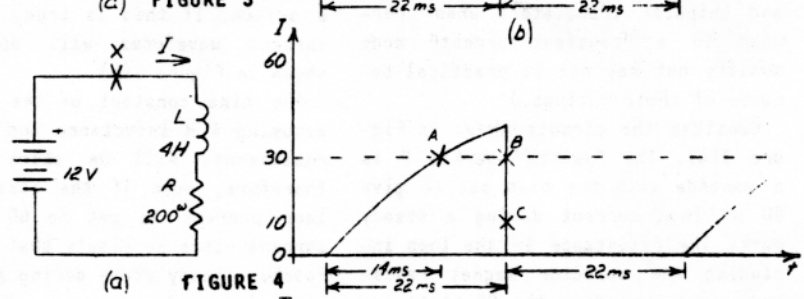
(a) FIGURE 1 (b)



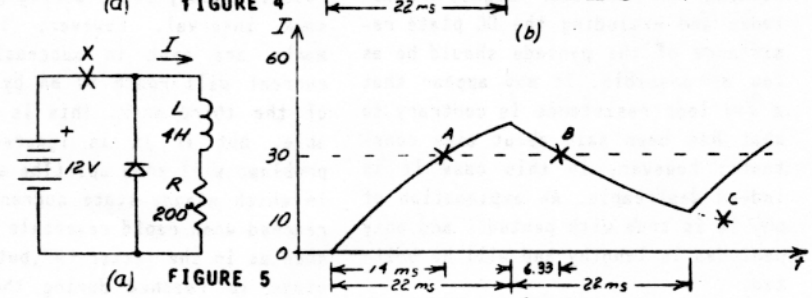
(a) FIGURE 2 (b)



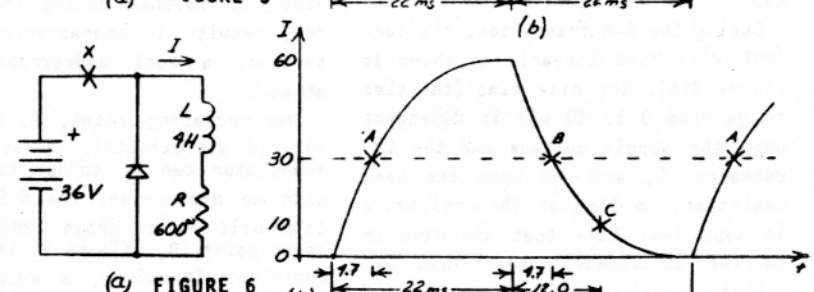
(c) FIGURE 3 (b)



(a) FIGURE 4 (b)



(a) FIGURE 5 (b)



(a) FIGURE 6 (b)

conduction, a bipolar transistor driven into saturation, a unipolar transistor driven into the ohmic region, or a vacuum-triode. (It is tacitly assumed that the devices can be safely turned off rapidly.)

The only difference in current waveshapes between the "triode" and metallic contact circuits would be a vertical drop in current during the M-S transition because no C.P. network is used. The bias would be 5.8% and 2.9% spacing for the 130-volt and 260-volt loops, respectively.

A "PENTODE" SWITCH

A pentode vacuum-tube operated in a "constant-current" mode as a selector magnet driven presents a complex situation that requires quite a bit of reasoning to fully explain. Therefore, we will only describe the requirements for best operation and the resulting waveshapes.(The term "pentode" is being used generically; it includes any device having a "pentode-like" characteristic. Bipolar and unipolar transistors when operated in a "constant-current" mode qualify but may not be practical because of their ratings.)

Consider the circuit shown in Figure 3(a). The "switch" marked P is a pentode with the bias set to give 60 mA loop current during a steady mark. The resistance in the loop including the selector magnet resistance and excluding the DC plate resistance of the pentode should be as low as possible. It may appear that a low loop resistance is contrary to what has been said about time constants; however, in this case it is indeed desireable. An explanation of why it is true with pentodes and only pentodes is lengthy and will be omitted.

During the S-M transition, the current will rise linearly as shown in Figure 3(b). The rise time (the time to go from 0 to 60 mA) is dependent upon the supply voltage and the inductance, L, and not upon the loop resistance so long as the resistance is kept low. Note that the rise in current is linear rather than exponential as in all preceeding and all following examples. The rise time for a 130-volt source and L-4 H is 1.85 ms, placing point A about 0.93 ms delayed, and for a 260-volt source the rise time is about 0.92 ms, delaying point A by 0.46 ms.

During the M-S transition, the resistance of the tube is nebulous, but is very high giving a very short time constant. Therefore point B will be undelayed. As a result, the bias will be 4.2% spacing and 2.1% spacing for the 130-volt and 260-volt cases, respectively.

LOW-VOLTAGE TRANSISTOR DRIVERS

Figure 4(a) shows a loop consisting of a 12-volt supply and a "switch", X, which represents the C-E "junction" of a bipolar transistor. In this circuit the total loop resistance, R, will probably be composed of only the winding resistance of the selector magnets. Because of parameter variation problems the transistor will probably have to be operated in the saturated mode. Therefore the transistor will act very much like a switch. If this is true, the loop current waveforms will appear as shown in Figure 4(b).

The time constant of the circuit, assuming 4 H inductance and 200 ohms resistance, will be about 20 ms. Therefore, even if the steady-state loop current is set to 60 mA, the current rises so slowly that it never reaches steady-state during a typical mark interval. However, if three marks are sent in succession, the current will reach 60 mA by the end of the third mark. This is intolerable, but if it is ignored, other problems will show up. (The situation in which steady-state current is not reached when rapid reversals are sent such as in the letter "R",but steady-state is reached during the letter "M", results in characteristic distortion, a most undesirable situation.)

The operating point, A, has been shifted approximately 14 ms. If the transistor can be safely turned off with no protection, the M-S transition will be as shown, and the release point, B, will be in its normal position. Therefore, m equals 22 - 14-8 ms; the %Bias - 100 (8-22)/22--63 or 63% spacing bias! This is also intolerable.

The inductive kick occurring when the transistor is turned off may damage the transistor. This can be prevented by placing a diode in the circuit as shown in Figure 5(a).

If we can assume that the diode when conducting has the same characteristics as the transistor when it is conducting, the waveshapes will appear as shown in Figure 5(b).Again, we have the problem of characteristic distortion resulting from the time constant being so long that steady-state is never reached when alternate marks and spaces are being sent, but steady-state is reached when several marks or spaces are sent in succession. For this example the bias is 35% spacing.

If the supply voltage is raised to say, 36 volts, the loop resistance would be 600 ohms and the time constant would decrease to 6.7 ms. This is shown in Figure 6. Point A and point B are shifted about 4.7 ms. each so that no bias is present and the time constant is sufficiently short to allow steady-state conditions to be established by the end of each unit. (This curcuit appears to be satisfactory, but when an actual selector is considered, severe bias will exist.)

OPERATE AND RELEASE CURRENTS

As mentioned earlier, the selector operate current has to be higher than the release current and may be several times as great. To illustrate this condition we will repeat the whole discussion(in abbreviated form, thank goodness!) Let us assume the operate current is 30 mA, and the release current is 10 mA. The point of operation, A, on all the diagrams will still apply, but the release point, B, will have to be replaced by point C.

In the simple contact-operated 130-volt DC loop shown in Figure 2(a), the shifting of the release point from B to C will slightly decrease the bias because point C is delayed by about 0.6 ms;the bias will be 3.1% spacing. Using a 260-volt source give 0.6% spacing bias.

When using the "constant-current" pentode with a practical selector, the bias will be the same as it was with the "semi-ideal" selector. 4.2% and 2.1% spacing. Although points B and C are at different current levels, they are in the same time position because of the vertical nature of the M-S transition. This has a very important consequence: If the M-S and S-M transitions in the current supplied to the selector magnets are nearly vertical, i.e., have very short time constants or rise times, the operate and release current values will not in themselves affect selector operation. As a corollary, when rise times are long, selector operation is very dependent upon the selector operate and release current values.

In the case of the 12-volt loop with a transistor and diode (Figure 5), the selector magnets will never release the armature! This phenomenon may manifest itself in a subtle manner. Assume a solid-state TU having this type output circuit is tested. With a steady mark at the input the output loop current is 60 mA, with a steady space it is 0 mA. When characters are sent the printer will copy infrequent-transition characters such as T, M, and O but will be unable to cope with frequent-transition characters such as J, R, and Y.

The transistor and diode with a 36-volt source (Figure 6), although showing no bias previously, will now show A delayed by 4.7 ms and C delayed by 12.0 ms; this gives: m-22 - 4.7 plus 12.0 equal 29.3 ms. Therefore the bias is: 100 (29.3 -22)/22 equal plus 33.1 or 33.1% marking bias!

MULTIPLE SELECTOR MAGNETS

If more than one selector is inserted into the loop, as in the case where a pageprinter and a reperforator are being operated simultaneously, the circuit analysis can be made with little additional effort. Essentially, in all the previous examples the time constants would be doubled; the bias would also double. This means that a circuit that is marginal with one selector in the loop (say 33% bias) will become inoperable with two in the circuit (66% bias). However, if the bias is only 1% initially, even four selectors will only result in 4% bias.

As selector magnets are added, the loop resistance will increase, lowering the loop current. The normal procedure for compensation is to employ a rheostat that is manually adjusted whenever a machine is added or removed. However, the change in loop current is smallest when the highest voltage source is employed. With a "constant-current" pentode no adjustment should be required.

HIGHER SPEEDS

The time constants of a loop are not dependent upon the speed of operation, but the length of a mark (and space) are shorter making the time constant a larger fraction of a unit. This has the effect of increasing the bias as the speed is increased.

MISCELLANEOUS

The voltage appearing across the selector magnets has been totally ignored; its magnitude is useless except as an indirect indication of the steady-state loop current flowing in the magnets.

Traditionally, polar relays were used for many reasons; two reasons are: (1) The operate and release currents are nearly equal, and (2) The inductance of the relay winding is relatively low.

Because of these two characteristics, the relay will approach, closely, the "ideal" selector originally discussed, and as a result, will give better performance than a "barefoot" selector in a poor loop as well as not additionally "fouling up" the loop by adding a lot of inductance. This is why so many Model 15s come with a 255-A inside.

The selector within a Model 32 is driven from a solid-state unit built within the machine. When inserted into a loop it does not reflect the selector inductance back into the loop. The solid-state driver does for a Model 32 what the 255-A did for a Model 15.

CONCLUSION

The inductance of the selector magnets introduces time delays into a telegraph loop. These delays can affect operation to the point of total failure. The amount of delay is dependent upon the inductance of the selector magnets and the resistance of the loop. The larger the inductance, the greater the delays; the larger the resistance, the smaller the delays. Thus resistance can be used to offset the effect of inductance.

Because the loop resistance is directly proportional to the loop supply voltage, a good (but not infallible) figure-of-merit for telegraph loops is the DC supply voltage. The higher the supply voltage, the better the loop.

The actual effect of the time delays is dependent upon the operate and release currents of the selector; these values are dependent upon the design of the machine as well as the adjustment. However, the shorter the delay, the less the effect it will have upon the performance of the teleprinter regardless of the design and adjustment.

The best loop is one containing a 260-volt DC supply and a "constant-current" pentode. Second choice is a 260-volt DC loop containing metallic contacts or a triode. Any loop containing less than a 130-volt DC supply should be viewed with suspicion unless that "loop" was designed by the manufacturer of the teleprinter upon which it is used.

For those interested in experimentation, waveshapes similar to those described can be viewed on an oscilloscope. Use a good signal source; the best for this application is the I-193 Polar Relay Test Set because is supplies a continuous series of alternate marks and spaces at "60-speed." Place a low value non-inductive resistor in series with the loop at the ground end of the loop; place the oscilloscope across the resistor.

We would like to thank Doug Kerr,

W2AIE, for many comments and suggestions.

USING A MILLIAMMETER IN A LOOP

Frequently, questions are asked about why a dc milliammeter acts the way it does when placed into a telegraph loop. The following will (hopefully) explain its behavior.

A dc meter (voltmeter or milliammeter)is an average-reading device.This means that the indication given by the meter is the average (with time) of the current flowing thru it.

If a very slowly alternating current is applied to a milliammeter, the meter will respond to the varying current and will, at any instant of time, give a reading corresponding to the current flowing at that instant of time, if a true alternating current were applied, half the time the meter would be going down scale because the current is reversed half the time and the deflection is directly proportional to the current flowing, including polarity.

The meter movement, although fairly lightweight, still has some mass and cannot, therefore, respond instantaneously. If the alternating current applied to the meter is increased in frequency, the meter may not be able to respond rapidly enough and the reading given by the meter will be less than it was previously, even if the actual current being applied has the same magnitude. Remember, the higher the frequency, the faster the current (or voltage)varies with time.

If an even higher frequency alternating current is applied (60 Hz is sufficient with most dc meters), the meter time to respond becomes so slow relative to the rate of variation of the ac that the meter will read zero. In other words, by the time the meter starts to respond upscale, the applied ac has already reversed, and it is trying to make the meter read downscale, etc.

It is under the condition where the applied current is varying more rapidly than the meter can respond that the dc meter is truly average-reading. The average of a sine wave is zero, and that is what the dc meter reads so long as the meter "sluggishness" is sufficient to keep it from responding instantaneously.

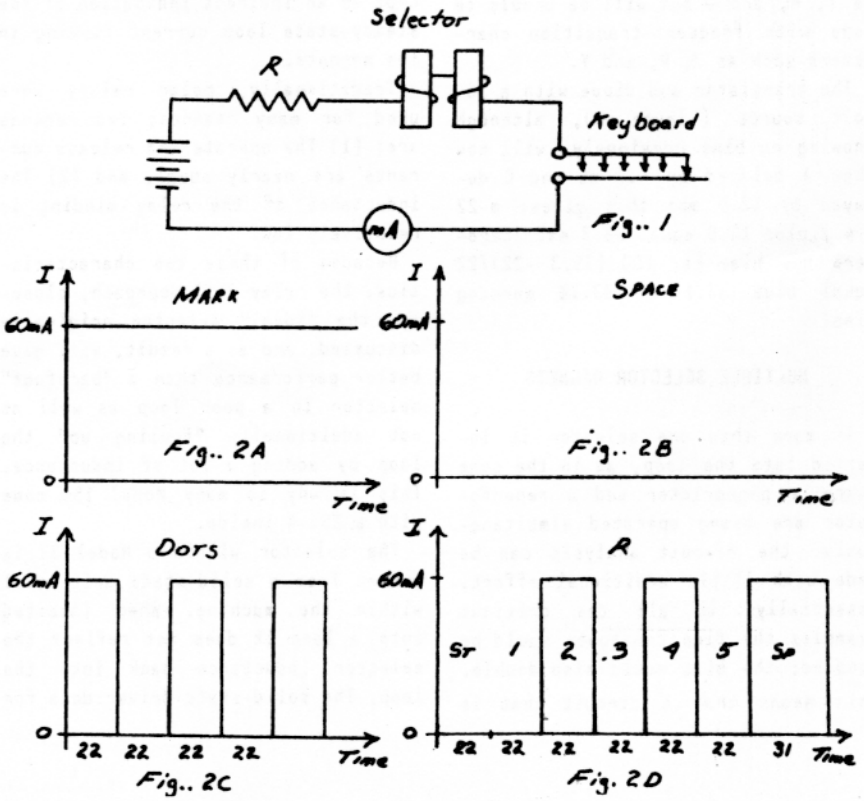
A simple, but typical, telegraph loop is shown in Figure 1. The loop consists of a loop supply, some resistance, the selector magnets in the printer, the keyboard contancts, and a dc milliammeter. Assume for purpose of discussion that the dc milliammeter is 60 mA full scale. Also assume that the selector in the teleprinter is a 60 mA selector. Regardless of the loop supply voltage (which should be at least 130 V dc), the resistor is to be adjusted to give 60 mA loop current when the keyboard contacts are closed. (If the loop is keyed by a polar relay, a vacuum tube, or a transistor, the discussion is still exactly the same.)

When the contacts are closed, the meter reads 60 mA. When the contacts are open, the meter reads zero. (Closed contacts correspond to a Mark and open contacts correspond to a Space). Figure 2A shows current (I) versus time for a steady Mark, and Figure 2B for a steady Space. These pictures are as would be seen on a dc oscilloscope.

What happens when a telegraph character is sent; i.e., when someone is "typing" something?

For initial explanation purposes, assume that the keyboard can send "dots." Dots are simply constanty repeated opens and closures of the loop in perfectly even intervals. Figure 2C shows how the loop current would vary when dots are sent (and there is no loop inductance). This is simply a square wave. During the first interval when the current is 60 mA, the meter will attempt to travel from zero toward 60 mA. However, if it is a typical meter, 22 milliseconds is not sufficient time for the meter to respond from zero to 60 mA.Therefore, it will only get part way up toward 60 mA when th loop current goes to zero. The meter will then try to return to zero. However, it was moving upward and will require a while to stop moving upward before it can start to move downward. It will probably be able to start moving downward but will not get to zero before the current goes to 60 mA again, and it again has to reverse and start going upward, etc.

Consequently, the meter will not read zero and will not read 60 mA,



but will hover between the two values. If the meter is sufficiently sluggish (most meters are), it will appear to stand still somewhere between 60 mA and 0 mA. The question is: Where will it appear to remain stationary? Well, the meter is spending half its time trying to go to 60 mA and half its time trying to go to 0 mA. (Note, that when the dots are being sent, exactly half the time the current is 60 mA and exactly half the time the current is zero.) Therefore, the meter must indicate exactly half of 60 and 0, or 30 mA.

If the meter is less sluggish, it will not sit steadily at 30 mA but it will appear to hover or vibrate about 30 mA.

What happens when a single repeated RTTY character such as R is being sent thru the loop? Figure 2D shows the current as a function of time in the loop. As in the previous example, the meter will spend part of its time trying to get up to 60 mA and part of the time trying to go to zero. However, in this case the two portions of time are not equal. Because the meter indicates a simple average, the expected meter reading can be calculated as (22x0 plus 22x0 plus 22x60 plus 22x0 plus 22x60 plus 22x0 plus 31x60)/163 equals 27.6 mA. Or: 75x60/163 equals 27.6 mA. Therefore, the meter should read 27.6 mA because this is the average.

In order for the meter to indicate the value just calculated, several conditions must be met: The steady Mark current must be exactly 60 mA, there is no inductance in the loop (inductance distorts the wave shape), the contacts on the keyboard are properly adjusted, the keyboard is being keyed at keyboard speed, and a Bell System machine with a 7.42-unit code is being used. These may seem to be unduly restricting, but that's life! If any one of the above conditions is not met, the meter will not read exactly 27.6 mA. This can be used as a good indicator for all components in the loop. However, if two (or more) of the above conditions are not met, the meter could read 27.6 mA. Therefore, the above is not an infallible check, but it is a simple, useful indicator.

When the repeated character, such as R is sent, the meter may appear to fluctuate more than with dots. The reason is that the start pulse and the first unit are both spaces;therefore, the meter has a longer time to move during this interval.

When just "typing" on the keyboard, the meter may appear to move somewhat erratically. This is to be expected, because the meter is constantly trying to find an average, and each character has a different average (or nearly so). Also, the time spent between characters is a variable depending upon the "typing" speed of the operator.

In summary, when a dc milliammeter is used in a loop, it will indicate something other than 60 mA (Mark) and 0 mA (Space) when something is being sent in the loop. The meter cannot follow the rapid variations in loop current during the bit intervals within a character. When a steady repeated character such as dots or a letter are sent, most meters will indicate a steady current that is the average of the loop current. In the case of dots it will be 30 mA; for a repeated R, 27.6 mA; and for a repeated Y, 35.7 mA.

SUMMARY

We have been describing some of the fundamentals of RTTY. This has been done to give an overall picture of the various aspects of RTTY to someone who is new to the "art." We have now completed the opera, and will summarize what has been said.

THE TELEPRINTER

Printing telegraph machines communicate with each other (and within themselves) by means of a code commonly called the Baudot code. (Actually, it is not the Baudot code but the Murray code which is used by the common Teletype machines.) For an extremely good discussion of the historical and present aspects of printing telegraphy see: "Pinciples of Telegraphy (Teletypewriter)" Navships 0967-255-0010, June 1967, SD catalog number: D219.8:T23. The code is composed of five even-length "pulses" or elements. Every character sent from a keyboard contains the five pulses. This is unlike the familiar hand keyed "CW" code which contains many different length characters. The teleprinter requires that all characters be the same length because both the sending and receiving machines are mechanical things, and mechanical things are best suited for operation under repetitive conditions. (The same argument applies to the all-electronic keyboards and "printers", but the problem is not as severe with them.)

The code is generated by the keyboard. When a key is depressed, the machine translates the letter to be send into the proper code combination corresponding to that letter and then sends the code. The receiving machine receives the code for a given character, then selects (or decodes) the character being received, and prints it. It should be noted that a complete teleprinter, although it may, from the outside, appear to be similar to a typewriter, is actually quite different inside. Basically, it consists of two completely separate and independent machines - a sending unit called the keyboard and a receiving unit called the printer. Usually the only thing common between the two units is the motor which drives both of them and the cover which is used to keep dirt and fingers out and the noise in. (Can't say it is very successful at any of those things!)

The "pulses" in the code used by teleprinters consist of an open circuit, called a Space, and a closed circuit, called a Mark. Because there are only 5 "pulses" per character, only 32 characters are possible. More than 32 characters are needed (just the 26 letters and 10 digits equal 36, and some puntuation is desirable, etc.) Therefore, most of the code combinations are used for two different characters; this explains why the keyboard is different from that of a typewriter. The dual use of characters is accomplished by shifting the machine into "Letters" or "Figures" position. Once a shift is accomplished, the receiving machine prints the characters corresponding

to that shift position until a shift of the other type is received. (An exception to this is found in some machines which are equipped with an "unshift on space" arrangement whereby a shift to "Letters" occures whenever a LTRS or a character space is received.)

Although only 5 elements are used in the teleprinter code to convey information, two other elements are needed.(Therefore, it is called a 7 or 7.42 unit code.) One of the additional elements is called a "Start pulse"; it is always a Space, and it precedes the first actual character code element. It was explained that the start pulse is needed to alert the receiving machine that a character is coming, and it is used to start the timing process within the receiving machine. The other extra element is called a "Stop pulse". It is always a Mark and it follows the last character code element; its purpose is to provide a period of time between the end of one character and the beginning of the next character so that the receiving machine can finish the decoding process and start the printing process before the next character arrives.

THE LOOP

A Teletype machine is made to communicate with itself or other machines by connecting the keyboard contacts and the selector magnets into a series circuit along with a variable resistor and a DC power supply of at least 130 volts. Essentially any number of machines can be connected into this series loop, although too many selectors will tend to distort the code pulses and may cause errors. Once the machines have been connected, the variable resistor is adjusted until 60 mA is flowing in the loop. The voltage across the selector magnets in any machine is irrelevant: the current flowing is what is important - however, the power supply in the loop must have at least 130 volts.

TRANSMITTING

The opening and closing of a loop by the keyboard can be transmitted by radio using two different, but closely related, methods.

In one method, called audio frequency shift keying (AFSK), the keyboard contacts are connected to an audio frequency oscillator; an oscillator built for this purpose is called an AFSK keyer. When the contacts are closed (Mark), the output frequency of the oscillator is 2125 Hz. When the contacts are open (Space), the frequency is 2295 or 2975 Hz (depending upon whether narrow or wide shift is being used, respectively). The output of this oscillator is connected to the audio (microphone) input of a voice (DSB AM or FM) transmitter. AFSK is usually used on 2 and 6 meters. AFSK when used with a DSB AM transmitter is called A2 modulation and when used with an FM transmitter is called F2 modulation.

The other method of transmission is called frequency shift keying (FSK). The keyboard contacts are connected to the oscillator in a CW transmitter. The connection to the oscillator tuned circuit is made thru a diode and an RFC. (The actual circuit depends upon the specific make and model of the transmitter and upon the method of connection from the keyboard). When characters are sent, the contacts on the keyboard open and close and this changes the frequency of the transmitter. The frequency change is very small; usually, the Space frequency is either 170 or 850 Hz above the Mark frequency. Note that unlike CW, the transmitter is on the air continuously; the only difference between a Mark and a Space is a slight difference in the output frequency of the transmitter. FSK is usually used on 80 thru 10 meters. FSK is called F1 modulation.

FSK can also be generated by a hybrid of the two methods just described. The output of an AFSK keyer is fed into the audio input of an SSB transmitter. Because the transmitter suppresses one sideband and the carrier, the output signal appears identical to that of a directly generated FSK signal.

RECEIVING

When receiving an AFSK signal, the receiver is tuned as it would be for a voice signal. The output from the receiver is connected to the input of a terminal unit (TU). The output of the TU is connected into a loop containing the selector magnets of a teleprinter. The TU "listens" to the tones. When a Mark tone is received, the TU allows current to flow in the loop; when a Space tone is received, the TU stops current flow in the loop.

FSK is usually received in a manner similar to CW. The BFO in the receiver is turned on and the FSK is automatically converted to AFSK by the receiver. The receiver tuning is more critical than it is with CW because the receiver tuning determines the frequencies of the AFSK signal appearing in the output, and the frequencies must correspond with the frequencies for which the TU is built. Once the receiver has converted the FSK signal to AFSK, the remainder of the receiving process is the same as it is with AFSK.

AN OVERALL VIEW

The whole sending and receiving process can be summarized by saying that when the keyboard contacts are closed, the transmitter sends out the Mark frequency; the receiver output will be a Mark tone and the TU will close the receiving loop. When the keyboard contacts are open, the transmitter sends out a Space frequency, the receiver output will be a Space tone, and the TU opens the receiving loop.

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"WHY WORK RTTY?"

RTTY is one of those quickly growing "specialized" forms of amateur communications. The attraction to its devotees is probably a mixture of the magic of modern digital communications coupled with the convenience of written rather than coded or voice communications. If you participate in the popular autostart nets, it's not even necessary to be home when receiving a RTTY message--the printer or display will record the text for you to read at your convenience. RTTY is very popular among "rag-chewers" and "engineers" alike; in fact, you get to do a bit of both. The rapid growth of digital electronics has carried over to both RTTY and the new home computer hobby. ASCII communications between Ham computers has received final FCC approval. If your "bag" is chasing DX, what could be more satisfying than a DXCC certificate for all RTTY? There are several DX RTTY contests sponsored every year with heavy participation. So, rather than ask "Why?" ask "How?"

"WHAT DO I NEED TO WORK RTTY?"

A ham RTTY station needs a transmitter, receiver, and antenna just like any RF communications system, in addition to some "special boxes" to make the RTTY part work. Some considerations for the equipment are outlined below:

1. RECEIVER - TRANSMITTER

The RTTY receiver and transmitter (or transceiver) should be stable, well calibrated, and capable of EXTENDED TRANSMITTER OPERATION. When you are transmitting RTTY, the full carrier is on for longer periods of time than for CW or SSB voice. So, check your manual and manufacturer for RTTY specifications and, if in doubt, reduce transmitter power somewhat. For HF work, a good SSB rig in LSB mode works well with RTTY tones (more on tones, later). Most VHF-FM transmitters work with RTTY, but avoid overloading the transmitter as mentioned above.

2. ANTENNA

A good antenna will buy you the same benefits in RTTY as it does in other modes. One caution though, the traps on some antennas may not handle as much power in continuous RTTY operation as they do for CW or SSB voice. This can especially be true of trap yagi antennas for the HF bands.

3. RTTY DEMODULATOR

The demodulator connects to the receiver audio output and converts the RTTY tones to keying pulses. The quality of your printed signal is determined more by demodulator performance than by any other portion of the system. Demodulators come in all shapes, sizes, and prices. HAL offers the feature-packed ST-6000 with active filters, scope, autostart, anti-space, ATC, DTH, and KOS, as well as the lower cost ST-5000. The popular ST-5 and ST-6 parts kits are also still available for the skilled technician.

4. TONE KEYER

The tone keyer circuitry converts the keying pulses from your keyboard into audio tones to drive the transmitter. Since this circuitry is closely related to that of the demodulator, both are supplied in the same cabinet in all HAL demodulators.

5. TERMINAL

The terminal is the device that prints or displays the received signals while allowing you to type your transmitted message. The terminal is sometimes divided into a keyboard and a printer or display section. The terminal can be as simple as an old surplus TTY machine or as exotic as the microprocessor controlled HAL DS3100 ASR terminal. An important feature of HAL Communications terminals is that ALL HAL RTTY EQUIPMENT IS LOOP COMPATIBLE WITH TTY MACHINES. This means that you can add HAL electronic equipment to your RTTY system at any time. The advantages of the HAL electronic terminals are many; ranging from lack of noise and oil (keeps the XYL happy and your nerves soothed) to automatic operator features such as real-time editing of typing errors, programmable identification message, and automatic carriage return/line feed operations. Also, the speed of the electronic terminal is easily changed with a front-panel switch. Machines require an expensive gear box or a manual change of gears to change speed. HAL offers the DS-3100 ASR and the DS2000 KSR terminals. The DS3100 ASR, DS2000 KSR, and the earlier DS-3000 KSR all work the standard ASCII computer code as well as the normal amateur BAUDOT code.

"HOW DO I HOOK IT UP?"

Probably the most frightening thing to the RTTY beginner is the thought of all those wires that must be connected to make it work. A particularly complicated RTTY station can have a real "rats-nest" of wires, but it didn't start that way. Make connections in a logical and step-by-step manner and all will work well. All transceivers are slightly different, but, in general, you will have to make these connections:

1. GROUNDING

Before making any other connections, decide approximately where your equipment will be located and run short, low-inductance ground wires (shield braid recommended) between the cabinet grounds of all equipment AND MACHINES. Do not defeat the AC safty ground on the HAL power cords; run separate RF grounds in addition to the AC safety ground. LACK OF ADEQUATE RF AND SAFETY GROUNDS CAUSES MORE PROBLEMS IN RTTY INSTALLATION THAN ANY OTHER SOURCE.

2. RECEIVER TO DEMODULATOR

Use shielded cable to connect a 500 ohm audio output of the receiver to the demodulator audio input jack. If

you do not have a 500 ohm output, the 4-8 ohm speaker output will work, but not as well; a speaker to 500 ohm line transformer would be a good part to add when possible.

3. TONE KEYER TO TRANSMITTER

Use shielded cable to connect the tone keyer output of the demodulator to the transmitter audio input.Often, a rear-panel "phone-patch" or "auxilliary input is provided. If not, connect directly to the microphone connector.

4. DEMODULATOR TO TERMINAL

Use shielded cable to connect the terminal to the demodulator. Use the curent loop connection for each. When connecting to a solid-state terminal, be sure to observe the proper polarity as indicated in the operator's manuals. Be extremely careful when wiring the loop circuit--potentially lethal voltages are present when the equipment is turned on (200 VDC @ 60 ma). Also, be sure that no part of the loop circuit is connected to chassis ground in machines or other equipment. All RTTY equipment is connected in series when the current loop output is used.

5. CONTROL CIRCUITS

Since the control requirements differ with manufacturer, study your transceiver manual carefully to determine how to control the transmit-receiver function. Usually, you can control the push-to-talk (PTT) line through a pin on the microphone connector, a front panel switch, or a rear panel accessory connector. Initially, try to manually switch between transmit and receive until you are familiar with RTTY operation. Eventually, you will probably want to take advantage of the automatic Keyboard Operated Switch (KOS) feature of the DS3100 ASR and ST-6000. KOS is the RTTY equivalent to VOX; typing on the keyboard puts you into transmit mode. If you pause long enough, the KOS "drops-out" putting you back into receive mode. KOS is particularly convenient for short exchanges.

"WHAT IS THIS MARK AND SPACE BUSINESS?"

The RTTY signal from the terminal is a series of pulses. The amateur BAUDOT RTTY signal has 7 possible pulses for each character typed or printed, each transmitted one-after-another (serial). Each pulse can be either "ON" (current flow in the RTTY loop) which is called "MARK" of "OFF" (no current flow), the "SPACE" condition. To keep decoders synchronized, the first pulse of a character, the START pulse, is always a SPACE (current off); the last pulse, the STOP pulse, is always a MARK (current on). The 2nd through the 6th pulses can be either MARK or SPACE, depending upon the coding required for a character. The START and all 5 data pulses are the same length; the STOP pulse may be either equal to or longer than the others. The so-called computer ASCII code uses START and STOP pulses but has eight instead of five intermediate data pulses, thus allowing a greater number of characters to be encoded. Although all machines and HAL electronic terminals use pulses, the MARK and SPACE pulse conditions are converted into MARK and SPACE audio tones for easy radio transmission.

"WHAT IS THE DIFFERENCE BETWEEN FSK AND AFSK?"

Transmitting RTTY signals via radio could be done like Morse code with on-off keying of the transmitter carrier. However, the interference received during off-times would give badly distorted printout. Rather, HF RTTY is transmitted with Frequency Shift Keying (FSK) so that the mark pulse condition corresponds to one radio frequency and the space to another. Amateur radio convention has it that the mark radio frequency is higher than space and that the separation of "shift" of the signal is standardized at 170 Hz or 850 Hz. (425 Hz shift is also used by commercial RTTY stations.) Most present-day amateur RTTY stations use 170 Hz shift exclusively. The FSK signal is received with the BFO turned on, giving two audio frequency tones for the mark and space conditions. The audio tones are, in turn, detected in the demodulator and the resulting pulses drive the display or printer. Note that changing the transmitter or receiver frequency (on purpose or through frequency drift) will change the audio output frequency to the demodulator. The HF system is therefore quite drift sensitive. Present HF equipment frequency stabilities are quite adequate for FSK RTTY, but it is only very recently that VHF equipment was available with similar stability. Therefore, VHF RTTY has traditionally been transmitted by first keying audio tones with the RTTY pulses and then using these tones as the audio modulation of an AM or FM VHF transmitter. This is called AFSK for Audio Frequency Shift Keying. Current amateur convention is to make the mark audio frequency lower than the space frequency by the amount of the shift. Since the RTTY data is audio modulation of the carrier, frequency drift of either transmitter or receiver is less critical. The audio frequency of the tones transmitted is set to be the same as those in the receive demodulator.

The required radio frequency shift keying can be done in two different ways: shift the frequency of a transmitter oscillator directly with the RTTY pulses or use a SSB transmitter with audio tones. Direct FSK keying circuits are described in most amateur journals and are generally simple, but require modification of the equipment; generation of FSK with a SSB transmitter is as follows: If a Lower Sideband Transmiter (LSB) is driven with a 2125 Hz audio tone, the RF output of the transmitter will be at a frequency 2125 Hz BELOW the suppressed carrier frequency. A properly adjusted LSB transmitter will have NO OTHER output frequencies. If the input tone is changed to 2295 Hz (170 Hz shift), the RF frequency is now 2295 Hz BELOW the carrier frequency. Thus audio tones into the LSB transmitter have produced FSK carriers out of the transmitter. Note that, because the LSB mode was used, the 2125 Hz standard mark tone for VHF AFSK has become the higher radio frequency. Thus, the same demodulator and tone keyer can be used for both VHF AFSK and HF FSK operation. Often this use of audio tones with a SSB transmitter is mistakenly called "HF

AFSK"--actually the resulting output is true FSK, IF the SSB transmitter has no spurious outputs (such as carrier or unwanted side-band). Most HF RTTY amateur radio stations use audio tones with a SSB transmitter. Although "standard" audio tones for VHF Amateur operation have long been 2125 Hz for mark and 2975 Hz for space (850 Hz shift), limited audio frequency response of HF SSB transmitters and receivers has recently given rise to a second set of "standard" tones at lower frequencies ("Low-tones").

"HOW ABOUT HIGH- VS LOW-TONES?"

Historically, demodulator tones were set to 2125 Hz for mark and 2975 Hz for space reception of 850 Hz shift. When transmitter stability improved, 170 Hz shift was used and the space frequency changed to 2295 Hz (mark remained at 2125 Hz). These three tones were, and still are, a standard for U.S. Amateur RTTY. However, in the early 1960's, virtually all commercially available transmitters and receivers became filter-type SSB equipment with audio pass-band limited to speed frequencies, sometimes as narrow as 2.1 kHz (300 to 2400 Hz). Obviously, the 2975 Hz (850 Hz shift Space) tone will not pass-through such a filter and 850 Hz shift with these tones is not possible (although the 170 Hz shift is). Therefore, either the SSB equipment must be modified or different, lower-frequency tones must be used if 850 Hz RTTY shift is desired. Both approaches have their advantages and both are currently in use. The so-called "LOW-TONE" standard sets mark at 1275 Hz and space at 1445 Hz (170 Hz shift) or 2125 Hz (850 Hz shift), conforming to the European IARU standard. So, there are now two sets of "standard" tones, LOW and HIGH (as well as a myriad of others), all of which work INTERCHANGEABLY on HF RTTY. However, since the actual audio tone is transmitted for VHF AFSK operation, the two sets are NOT COMPATIBLE IN VHF AFSK applications. Current U.S. Amateur operation uses the HIGH TONES for VHF. Thus, to use a demodulator and keyer for both HF and VHF operation, it should be setup for HIGH-TONE operation. Conversely, you may wish to have separate stations for HF and VHF, simplifying the cabeling, and providing simultaneous monitor/operation capability, as well as resolving the tone problem. The HAL ST-6000 and ST-5000 Demodulators are available for either HIGH or LOW-TONE operation.

"WHAT FREQUENCIES DO I USE FOR RTTY?"

HF RTTY Operation has evolved to heavy operation on the 80 and 20 meter bands (CW segments) with sporadic operation on other HF bands. 80 meter RTTY stations tend to operate between 3600 and 3650 kHz and 20 mter stations between 14.075 and 14.100 MHz. 170 Hz shift is used almost exclusively with mark being the higher radio frequency. 60 wpm (45 baud) is the most popular RTTY speed, but 100 wpm (74 baud) is gaining in popularity.

VHF RTTY operation in most areas is concentrated on 2 meter FM with 146.700 MHz being the popular operating frequency. Virtually all stations are now using the "High-tones," usually with 170 Hz shift. As with HF RTTY, 60 wpm (45 baud) is most popular on VHF. Some areas now have RTTY-only repeaters on 146.10/146.70 MHz.

"WHO DO I TALK TO ON RTTY?"

RTTY enthusiasts run the full range of ages and interests, but tend to be technically inclined. The typical RTTY'er is always modifying his station, likes to talk, and usually has more ideas than you have printer paper (or display screen)! Some operators are good typists; most aren't. The DS3100 ASR letters-fill and editing modes make even a poor typist look good. Recently, the home computer hobby has become quite popular with RTTY people and you may find a lot of help in debugging your programs if that's your interest. There are an increasing number of DX stations on RTTY.

"HOW MUCH DOES IT COST?"

RTTY is like any other hobby--it can cost as much or as little as you want it to. If you buy used machines and build kits or your own design, the total RTTY cost can be quite low. Conversely, the DS3100 ASR and ST-6000 offer an ULTIMATE RTTY station that is expensive. Because all of the HAL RTTY products are current loop compatible, you can add devices as your interests (and pocketbook) indicate. For the beginner, HAL has the following recommendations:

1. DEMODULATOR

Assuming you already have a good transceiver and antenna, your first major RTTY purchase should be a good demodulator. The HAL ST-5000 makes a particularly good, cost-effective unit. If you select a high-tone ST-5000, it will be usable for either VHF or HF (170 Shift) RTTY operation; if you are only interested in HF RTTY (for short-wave-listening to press stations, for example), the low-tone unit may be a better choice. Conversely, you may wish to "jump-in" and get the ST-6000 from the first. Either way, put high priority on a GOOD demodulator.

2. TERMINAL

You can spend very little or a lot on the terminal. A surplus machine can often be aquired at a hamfest for little cash investment. However, by the time you figure out how it works, fix it, and buy parts and manuals the total cost may not be so low. If you do, you'd better be prepared with tools, oil, and patience. Newer machines require less work, but also cost more. On a feature-for-feature basis, either the DS2050 KSR, CT2100, or DS3100 ASR are more cost effective than other terminals presently available. Certainly a "solid" beginner's RTTY station would be the DS2050 KSR with a video monitor. For the more serious enthusiast, HAL offers the CT2100 or DS3100 ASR.

IMPROVED SCOPE DISPLAY

Irvin Hoff, W6FFC
12130 Foothill Lane
Los Altos Hills, CA 94022

INTRODUCTION:

Solid-state demodulators such as the ST-5 and ST-6 use relatively low-voltage power supplies as compared with tube type units like the TT/L, etc. As a result some oscilloscopes of modest gain give mediocre displays when used with these units. Additional tuned circuits could be used for more precise tuning and straighter lines on the scope, but these further reduce the voltage to the oscilloscope. Finally, some scopes have rather low impedance inputs that tend to unbalance the discriminator output and further reduce the voltage available. The following paragraphs will describe a simple and low-cost circuit that provides ample gain, very high input impedance, very low output impedance and excellent precision for sharp and accurate tuning.

THE CIRCUIT:

The scope output of the ST-6 is run through an isolation resistor. A 3.3 meg is suggested. After this, a parallel-tuned 88 Mh. toroid is connected to the non-inverting input (marked plus) to ground. The dual 741 op amp then amplifies the small voltage (approximately 70 milli-volts by this time) back up to about 10 volts peak-to-peak at the output of the op amp. The tuned toroid not only gives a very sharp, precise tuning display, it also has sufficient selectivity to give virtually straight lines on the scope in place of the customary "bananas" seen with simple linear discriminators.

The input impedance at the non-inverting input (marked plus) is very high, in the order of at least several hundred megohms. The output impedance is very low, typically less than one ohm. The circuit can be used successfully with low impedance scopes such as the Heath Monitorscope, etc.

COMPONENTS:

The dual op amp may be any of a variety of integrated circuits. Individual 741 units may be used which sell at places like Poly Paks. The Signetics N5558V is a dual op amp as is the Motorola MC1558G. If you have a nearby Radio Shack outlet, their item 276-028 is equally acceptable.

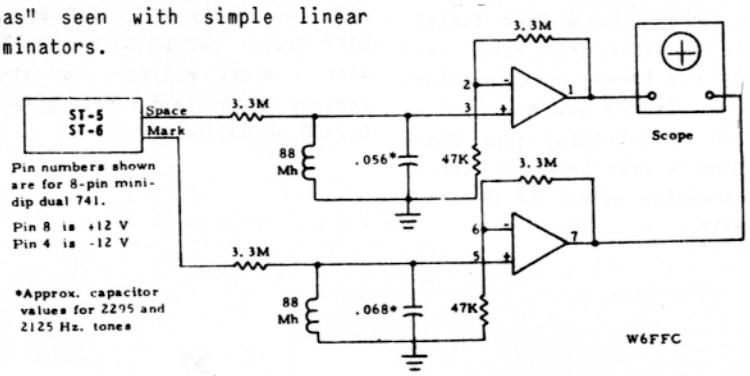
TUNING THE TOROIDS:

Use an identical technique to that used when constructing the demodulator in the first place. If a digital counter is handy, the entire job becomes fairly simple. One toroid is tuned for mark tone and the other tuned for space tone.

A suitable audio tone from the receiver may be used to tune the filters, but in this case use as large a resistor between the audio source and the tuned circuit as is convenient--at least 100K.

You can also tune the toroids "in place" in the circuit shown. The op amp not only will isolate the circuit but also has enough gain to allow use of normal VOM while tuning the toroids.

The output of this circuit is typically 10 volts AC, peak-to-peak. This should be substantially more than minimum necessary to run even the most modest scope.



SUMMARY:

The scope output voltage of solid state demodulators such as the ST-5 and ST-6 is relatively low. It may be insufficient to give a suitable display on oscilloscope with modest gain. In any event, the use of additional tuned circuits is quite advantageous as they will give a nice display with straight lines as well as good precision tuning. The circuit shown will accomplish this at a very nominal cost. The op amps are inexpensive and use the plus 12 and minus 12 volts available from the demodulator.

A NOVEL AFSK GENERATOR

Chuck Edwards, W6MNO
4726 Barbarossa Drive
San Diego, CA 92115

A novel AFSK generator - using a 8038 chip. This is a very simple circuit and is quite drift free after about five minutes of operation. The chip will, in addition to a sine wave, also produce a triangle and a square wave. However, we will use only the sine wave.

Space tone is set by trimmer R5 and mark tone is set by trimmer R3. The mark tone is obtained by grounding the base of the NPN transistor. Grounding the base causes the transistor to conduct and lower the voltage on pins 4 and 5 on the chip. Trimmer R8 is used to adjust the output level.

Please note that plus and a minus 12 voltages are required together with a common ground.

When adjusting the space and mark tones you may have to readjust as there may be a small amount of interact between the two adjustments.

This generator can be made on a very tiny perf board and stuffed almost anywhere. The only equipment you will need is a frequency counter and even that is not a necessity as you can get a buddy to help you over the air in making your tone adjustments.

**

CT2100

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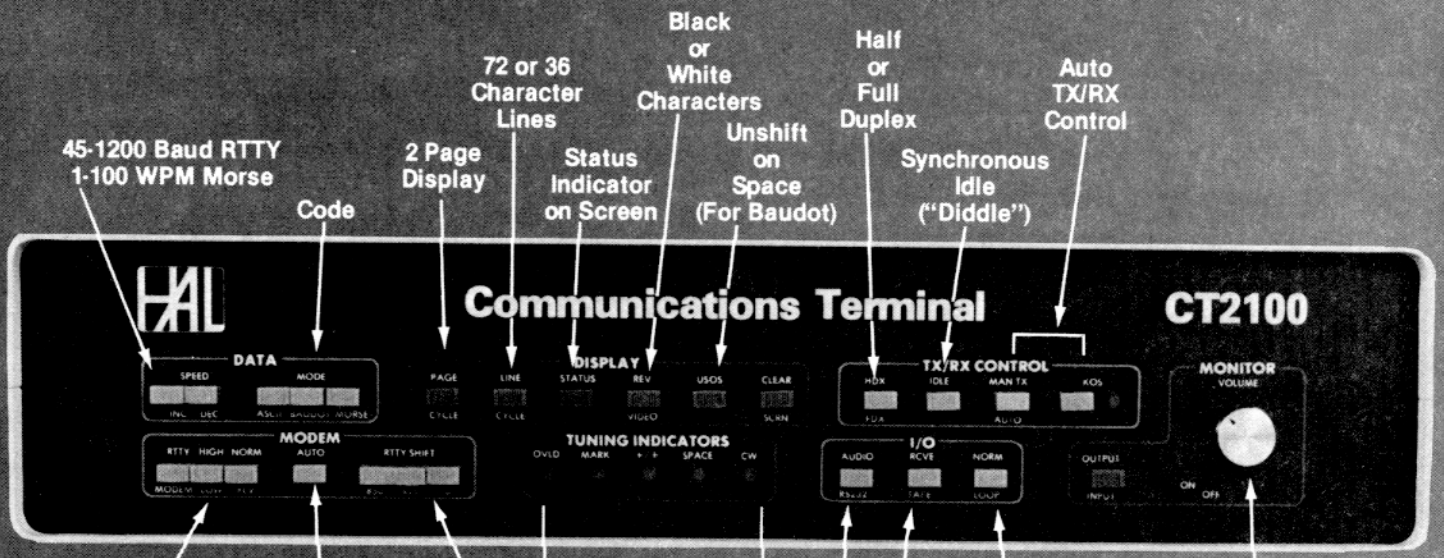

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  -or-
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Irvin M. Hoff, W6FFC

The ST-5 was designed to be as simple as an adequate demodulator could be. At the time it was offered, the ST-3 provided a modest-cost unit with autostart and motor delay. The ST-3 is now considered somewhat obsolete, partially because the General Electric PA-238 op amp is no longer available. After a number of people tried to modify their ST-5 for autostart by adapting portions of the ST-3 or ST-6, we decided to see if a simple autostart could not be developed directly for the ST-5.

The results have been quite satisfactory. One op amp and two transistors plus a relay have been used.

CHANGES TO THE ST-5

The only changes to the ST-5 needed to adapt the autostart section are the addition of a 33K resistor and parallel diode on the output of the slicer op amp. This is shown in the upper-left corner of the diagram. This makes the output of the slicer circuit identical to that of the ST-6. The input of the autostart is marked "AA", and connects to the emitter of the meter transistor.

ADJUSTMENTS:

There are literally no adjustments at all. The silicon diode on the non-inverting input of the 741 holds the bias on the op amp to approximately 0.7 volts. The divider network on the inverting input allows the voltage with authentic RTTY signal (properly tuned) to rise to approximately 0.9 volts. As the voltage rises higher than 0.7, the output of the op amp switches rapidly from positive output to negative output, turning the motor on and removing the voltage on the base of the keyer stage that was holding it in standby with no signal.

PROBLEMS TO CONSIDER:

There are a number of problems in designing a suitable autostart system. First it should ignore voice or C.W. on the frequency. To do this we require it to respond only to signals which are the equivalent of at least 70-80% key down, continuously. So it will not turn off too quickly for static bursts, momentary interruptions, etc., we ask it to continue for about 1 second after the signal stops. (At 60 speed, this would print about 5-6 random garble characters.) With this in mind, the turn-on time then would need to be about 3-4 seconds, or the equivalent of about 20-22 characters. Finally, we hope it will be able to copy stations at least 40-50 Hz off the frequency, assuming their shift is correct.

HOW IT WORKS:

With no signal, there will be a random voltage level showing on the meter. This should be significantly less in amplitude than the value shown on the meter when a signal is present and tuned in for maximum indication.

With no signal, the voltage at the emitter of the meter transistor is passed to the autostart curcuit through the diode, and then via the divider network charges up the 20 Mfd. capacitor. Due to the time constants involved, this voltage will not be as great as the 0.7 volts on the non-inverting input of the 741. Thus the op amp has positive voltage on its output. This is passed through one diode to point "AB" and holds the base of the keyer transistor in mark-hold. At the same time, the other diode blocks this positive voltage at the output of the 741, thus the motor control circuit is not activated and the motor remains off.

When a signal appears, the voltage at the meter rises, thus the charge on the 20 Mfd. capacitor at the input to the 741 also rises. As it passes 0.7 volts, the op amp switches abruptly, and now has negative voltage on its output. The diode at AB now blocks this voltage, allowing the keyer transistor to print the incoming signal normally, and at the same time the other diode allows this negative voltage to pass, quickly charging the 20 Mfd. capacitor at the base of Q3. As Q3 conducts, it puts voltage on the base of Q4, allowing it to conduct, operating the relay and turning the printer motor on.

When the signal stops, the voltage on the 20 Mfd. motor capacitor bleeds off slowly, due to the high impedance of the emitter-follower circuit. Approximately 25-30 seconds later, the motor turns off. This delay may be shortened by lowering the value of the 1M resistor in parallel with the 20 Mfd. capacitor, or by using a smaller value of capacitor. This time was chosen to keep the motor from turning off prematurely if a person was sending compulsory c.w. identification, or was a little slow in turning on his transmitters.

TRANSISTORS:

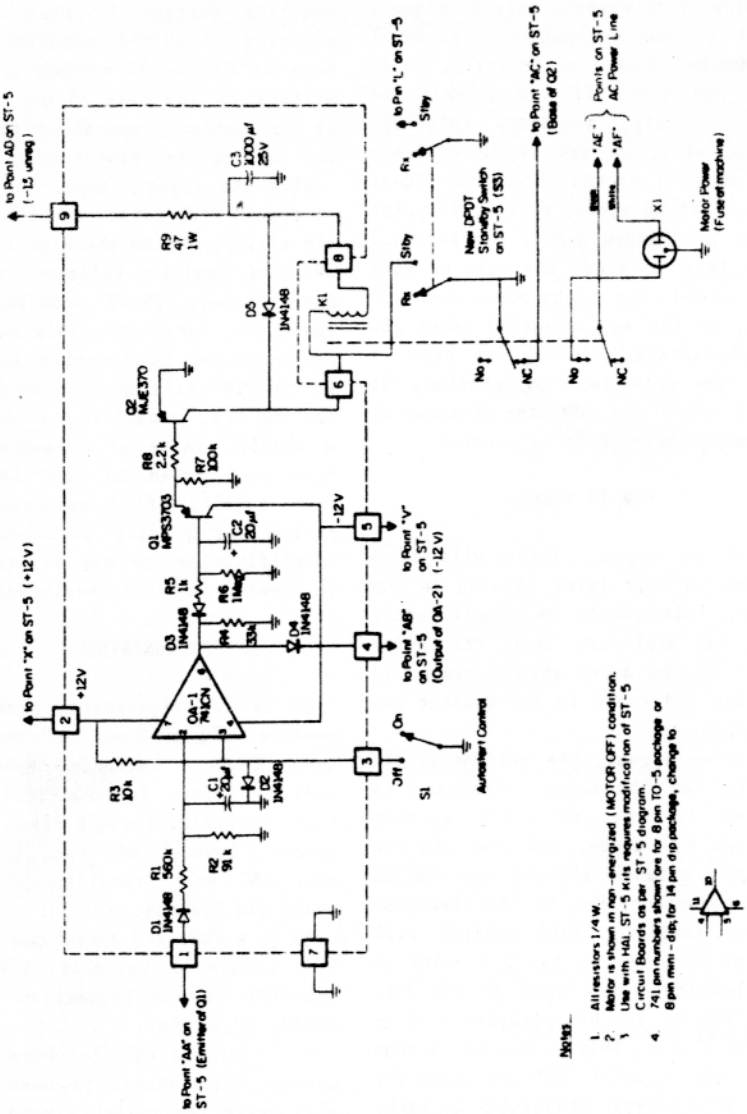
Q2 is any high-voltage transistor capable of handling 300 volts or more. Several suitable choices are made by Delco, International Rectifier, Motorola, the HEP line, RCA and others. Several of those firms now make 450 volt transistors that are small and low-cost.

Q3 is a PNP, and almost any silicon type should be suitable. A Motorola MPS-3703 is one suggestion and the 2N3906 is another.

Q4 is also a PNP, but here a high-current type should be used, as it will drive the relay. A good suggestion would be the Motorola MJE-370.

THE RELAY:

The relay is a 12 volt type with DPDT contacts rated at 10 amps. You could "get by" with 5 amp ratings, but the surge current on the motor would be a bit hard on this type of relay. A suitable relay would be the Potter & Brumfield KA11DG. As this is a 12 volt relay and you will be using unregulated "12 volts" to oper-



ate it, a series resistor of 47 ohms is shown to keep the current to that recommended in the relay. This resistor is only a suggested value and might need to be changed. The higher voltage is advantageous as a "starting kick" for the relay.

A diode is placed in parallel with the relay coil to prevent back emf from the inductive spike from damaging the transistor when the relay opens.

AUTOSTART OFF SWITCH:

In the event the operator wishes to turn the autostart off, S4 is closed.

STANDBY SWITCH:

The origianl standby switch was a SPST across the collector and emitter of the keyer transistor. This is still adequate, but at times the motor might turn off when transmitting, if the receiver is carried in standby, prohibiting the audio signal from operating the autostart. Changing the standby switch to a DPST and using the second pole to ground the collector of the Q4 transistor will keep the motor on while transmitting --quite often you will not be exactly on the same frequency with your receiver as you are transmitting on, and this will prevent the motor from turning off.

Another possibility would be to use the second section to parallel S4 during standby, as this would provide similar results, but keep the 20 Mfd. motor delay capacitor charged up as well.

THE MOTOR JACK:

Many printers have 3-wire plugs, so we suggest you use a polarized 3 way connector on the ST-5A. Many cases have been reported where a printer is 120 volts with respect to other items in the shack that are grounded. Using grounded connectors and 3-way wires to the printer should effectively prevent voltage differences from appearing. We would also suggest your using a 3-way cable and connector on the ST-5A, as well. Be sure the jack on the collector of Q2 for the teleprinter is insulated from ground.

TURN-ON TIMES:

If the turn-on time and turn-off times do not seem suitable, some adjustment can be made by changing the 91K resistor to the next larger or next smaller size. However, 3-4 seconds is considered normal for this type of autostart, and this is similar to the concept used on the other Mainline demodulators. If you insist on having a faster turn-on time, you could also use a smaller capacitor than the 20 Mfd. shown. That would still retain the 70-80% continuous key-down requirement to ignore c.w., etc.

CAUTION:

Be certain to use PNP type transis-

tors for Q3 and Q4, and note they connect to negative voltage. Also be careful to orient the capacitor on the base of Q3 with its positive terminal grounded!

CONCLUSION:

With only a minor modification existing ST-5 units, this autostart may be readily added. Its simplicity is in keeping with the design concept of the ST-5, which was to give adequate performance from a very simple circuit. Adding the autostart converts the ST-5 to a ST-5A. Boards and components for up-dating the ST-5 or for building the ST-5A are available from Hal Communications and from PEMCO. Autostart allows the operator to leave the room temporarily, or even to monitor a frequency 24 hours a day, unattended. Motor control makes the entire operation completely automatic.

UPDATED ST-5 MAINLINE DEMODULATOR

For those interested in 100 speed, change the 0.068 capacitor on the input to the slicer to a 0.039. A 741 may be used for the slicer if desired, in which case the 220 pf, 0.005 Mfd., and 1.5K components are left off, as the 741 is internally compensated. Regulated voltage has been added, as shown.

Both Hal Communications and PEMCO, and possibly others, offer boards, components, kits and ready-to-use St-5 units.

The ST- 3 was a successful solid-state design that introduced integrated linear operational amplifiers to rtty. It was still moderately complex, however, and fell short of the goal to supply the beginner with something that could be built in a few hours.

THE ST-5 DEMODULATOR

While developing a unit based primarily on ICs to replace the TT/L-2, a very simple modulator with great potential was developed: the ST-5. As with any simple circuit, the cost of the power supply is out of proportion with the rest of the unit. At 1970 prices the ST-5 costs only $14.50 less loop supply ($8) and a plus-minus 12-volt supply ($11).

The total cost of $33 is not overly impressive until you realize this unit can, if desired, be used as a building block for the more exotic ST-6.

Almost every component used here can be used in that unit.The ST-5 is a basis from which the beginner can expand--it's not just a collection of parts that will find no further use when he is ready to broaden his horizons to more sophisticated equipment.

FEATURES

The ST-5 uses two operational amplifiers (fig.1). One is an audio limiter, and the other is a trigger stage to drive the keyer. It has a 175-volt loop supply of the same type used in the TT/L, which provides plus-minus voltages for keying a transmitter and also features narrow-shift cw identification. Finally, the ST-5 has a symmetrical plus-minus 12-volt power supply.

LIMITER

The 709C op amp has over 90-dB gain and is good to over 10 MHz. It makes an ideal limiter. The zener diodes on the input don't assist in the limiting; they merely protect the 709C against damage in the event of excessive audio input (hardly likely but worth the protection). The limiter puts out square waves and is so powerful it starts working on input signals as low as 200 MV. The 25k pot merely balances the small offset input voltage for maximum gain. This voltage varies slightly from one unit to another, so a control pot was added rather than a fixed resistor, which many units use.

DISCRIMINATOR/DETECTOR

It's difficult to use the same value inductor with different capacitors and expect to obtain two similar filters of equal characteristics. To get similar band-width, voltage output, noise response, etc., some loading is necessary. Most simple demodulators merely balance the voltage or ignore all the problems completely. Without belaboring the point, it's not a simple job to get all these factors to balance suitably; but it is possible, and the Mainline units all have filters that have been designed with care.

The ST-5 offers a choice of the 2125-2975 mark and space tones (considered standard), or the 1275-2125 low tones necessary in some modern receivers. (Actually nearly all these receivers respond beautifully to 2975 tones and higher, but a new bfo crystal is needed.) The best results come from the 2125-2975 tones, since the two frequencies are only about 28% apart while the 1275-2125 tones are 40% apart; thus it's a more difficult job to separate the harmonics and achieve proper filter design.

The detector features full-wave rectification for most efficient filtering of the dc ripple remaining after the audio has been rectified. A simple RC low-pass filter removes the remaining audio components.

SLICER

The slicer takes the small voltages from the filters and changes them to roughly +10 volts for mark and -10 volts for space, regardless of the original amplitude. This in reality is a dc limiter, as a signal as small as a 100uV or so will cause the unit to saturate completely, either plus or minus, depending upon the polarity of the applied signal voltage. The unit has so much gain that at the cross-over point, a change at the audio input as small as one or two Hz will cause this trigger stage to flip from +10 to -10 volts. This is another way of saying shifts as low as 3-4 Hz could be copied on the ST-5 if tuned in properly.

KEYER STAGE

A 250-volt Motorola 20W transistor selling for $1.06 is used. The normal loop-supply current for TTY machines

is 60 mA. This transistor has a large amplification factor and acts like an on-off switch. When on, the power consumed in the transistor is only 0.012 W; so in the ST-5 there's no way you could ever damage that transistor.

An RC network in the 2N5655 collector takes care of the back emf developed by the inductance of the selector magnets in the printer during the transition from space to mark. The transistor is biased off during space. A diode in the base circuit keeps this negative voltage below the point at which the base-emitter junction would be reverse-biased.

STANDBY SWITCH

When S1 is closed, the unit is placed in mark. When S1 is opened, the printer can follow whatever is fed into the limiter from the receiver.

As explained previously, the unit has so much gain that a signal as small as 3-4 Hz can be copied if tuned correctly; this is called straddle tuning. However, for 170-Hz shift you may wish to add a switch that changes the space filter to the new frequency. Fig.2 shows the way this would be accomplished if using the normal 2125-2975 tones, and fig.3 shows the circuit for the low tones of 1275-2125. This is merely an expedient and doesn't result in proper filter balance, but it provides good 170-shift reception with the switch closed, or normal 850-shift reception with it open.

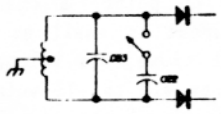


fig. 2. Switching circuit for adding 170 shift to space filter for 2125-2975 tones.

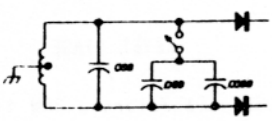


fig. 3. Switching circuit for adding 170 shift to space filter for 1275-2125 tones.

TUNING INDICATOR

Provisions are provided for connections to the vertical and horizontal amplifiers of a scope (fig.1). It is customary to connect the mark signal to the horizontal amplifier and the space signal to the vertical amplifier, although many reverse this method.

Most people prefer a scope indication, but an excellent tuning indicator is provided at point A (fig.1). A voltmeter connected to this point will give equal voltage indication for mark or space. With RTTY signals the meter should stand still. If it doesn't, retune the receiver until it does. If straddle tuning a signal, the meter may read less than normal, although it won't move. This is normal and merely indicates the shift being copied is not the correct shift for the filters you're using.

Fig.4 also shows how a 0-1 mA meter may be added. An inexpensive NPN transistor is used, such as the MPS-3394, although any NPN transistor would be satisfactory here. The capacitor merely dampens the meter so it doesn't flip around too violently. If your meter is too damped, remove the capacitor or try a smaller value. This was suitable for the inexpensive imported meter used in my unit.

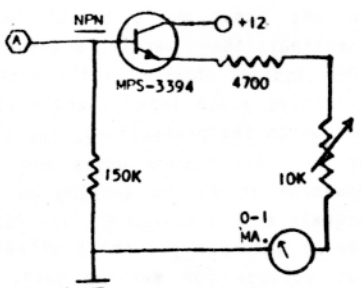


FIG. 4 OPTIONAL TUNING INDICATOR

THE TRANSMITTER KEYER

Fig.5 shows a typical FSK keyer for installation in the transmitter. The components can be mounted on a small terminal strip and placed near the VFO tube under a convenient mounting screw which also serves as a ground return. The trimmer is connected to the cathode of the VFO tube and the tube replaced in its socket; thus, no changes of any type are made to the transmitter and its resale value is not affected. There should be room for several keyers if you wish to have the convenience of both 170 and 850 shift.

Although a 3-12 pF trimmer is shown in fig.5, some transmitters only require a 1.5-7 pF trimmer. It is suggested that you do not substitute for the 1N270 diode as it is superior to most other types in this application.

If your signal is reported as "upside down," reverse the 1N270 diode. If you do not obtain sufficient CW shift with this connection (conduct on mark), the 500-ohm CW-shift pot should be connected to the opposite side of the 8.2k resistor at the junction of the two 15k resistors (fig.1).

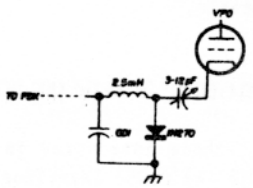


fig. 5. To add fsk to literally any transmitter, connect a 3-12 pF trimmer to the cathode pin of the vfo tube.

COMPONENTS

The 709C op amps are supplied by various manufacturers including Signetics, Fairchild, and Motorola. Prices are constantly being reduced as devices become availabe from more companies. When I first started working on a super deluxe demodulator in the fall of 1967, I paid over $10 each. Now they're too cheap not to use. The Motorola unit can be purchased through most distributors, including Allied and Newark. The Fairchild unit can be mailordered from the firms below. Specify the TO-5 can, as this is easier to work with than the dual in-line 14-pin type (same cost).

The diodes marked G in fig.1 are 1N270 germanium at 32¢ each. Those marked SIL are most any silicon type, such as the 1N2069. The one in the loop supply should, however, be a

minimum of 400 volts PIV. Fifty-volt PIV is suitable everywhere else.

The 88-mH toroids are available from various sources for about 40¢ each. They're wired in series for 88 mH, and the junction of the two windings is grounded.

If you have an accurate means of determining the frequency, you can tune the filters by removing turns of wire from each of the two sections concurrently to keep the turns ratio in the two windings the same. One turn from each of the two windings will increase the frequency about 6 Hz at the 2125 frequency, for example.

Use Mylar capacitors, such as the Sprague Orange Drop. Twenty-five-volt capacitors are adequate, but you'll probably wind up getting 200V types. They are only 15-21¢ each.

The pots can be the inexpensive Mallory PC board MTC types. Other power transformers may be used, but the Tiad F-40X is an excellent buy.

PRINTED-CIRCUIT BOARD

The printed-circuit boards hold all of the components except the two transformers and the control switches. This greatly enhances construction, and at the same time makes it possible for nearly anybody to build an extremely nice-looking unit. The printed-circuit board includes one section for the power supply and another for everything else. The board may be split down the middle and the two sections mounted back-to-back as I did in my unit, or the board may be left intact and used with a more shallow chassis.*

ADJUSTMENT

With no input signal, or with the input grounded, adjust the pot on the limiter for zero volts dc at pin 6. If this isn't possible, you'd better write me and explain thoroughly, as you probably ruined the op amp somehow. By the way, unless you get too much voltage on pins 2 or 3, like the full power-supply voltage, or get the plus-minus hooked up backwards, it's very difficult to ruin these things. By following even the most elementary construction practices, you'll have no problems with the 709C.

After balancing the limiter for zero volts output, connect the receiver and tune to maximum mark and note the indication on your tuning indicator (fig.4) or on a voltmeter connected to point A. Tune to space on the receiver and again note the reading. If the indications are not the same, adjust the 5k pot on the limiter output until they are. You have now finished all the adjustments and they should require no further attention at any time unless you switch to 170 shift, for instance. In this event you may or may not want to reset the filter balance pot. I suggest you leave it for the 850 setting and take what you get on the 170-switch position, as this is a somewhat artificial method of getting good 170-shift reception.

When transmitting be certain to first close the standby switch or you can get feedback, which will produce errors similar to those you would get when using a microphone if you didn't turn off the speaker.

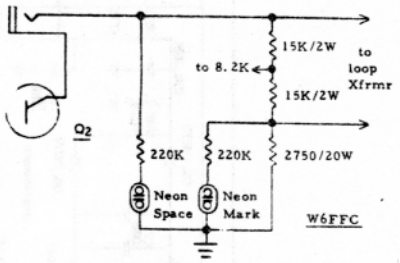
OTHER OP AMPS

The 709C is to other op amps what the Ford V-8 was to other automobiles. It not only led the way; it's still in use. The 709C was (and is) one of the cheapest ICs of its type available. One would gain very little and stand to lose a lot by trying to substitute other units. The 741 and 748, for example, have a bit more gain, higher input voltages, and require no frequency compensation. Their biggest disadvantage here is that they're not at all suited as audio amplifiers. At 2 kHz they have only 30-40 dB gain and make a poor audio limiter compared with the 709C. So unless you know what you're doing, stick to the 709C.

*Hamilton Electro Sales, 340 East Middlefield Road, Mountain View, Calif. 94040 and G.S. Marshall Co., 732 North Pastoria Avenue, Sunnyvale, Calif.94086 (also carries Signetics). If buying Motorola version, ask for the MC-1709CG. Texas Instruments 709 op amps are $1.50 each (or 7 for $10) from HAL Devices, Box 365, Urbana, Illinois 61801; ask for SN72709L.

MARK-SPACE INDICATOR LAMPS

Adequate indicator lamps to show mark or space are shown in the partial drawing of the loop supply. Any type of low-curent neons should be suitable. Their use does enhance tuning in a signal and they help to indicate if a station is upside down or not.



MARK & SPACE INDICATOR NEONS

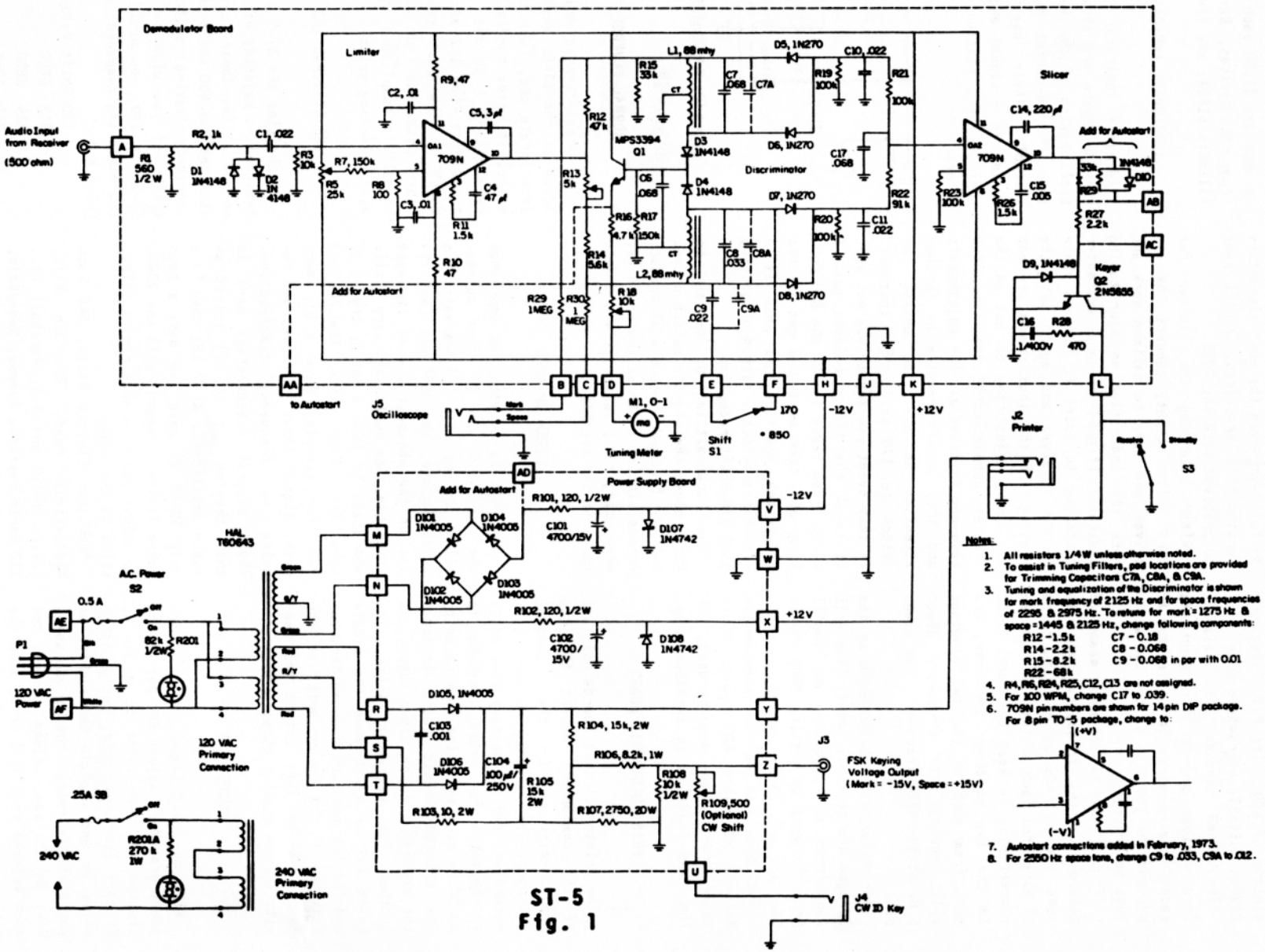
NORMAL-REVERSE SWITCH

No normal-reverse switch has been added to the ST-5. While possible to incorporate one, (see the St-6 schematic) it seems hardly necessary. At my station, I do not recall having heard more than 1-2 stations "upside down" in the past year. Using the other sideband on the receiver normally accomplishes the same thing as a reversing switch.

THE ST-5 AND 170 SHIFT:

At the time the ST-5 was originally designed, a majority of stations were on 850 shift. These days, only a few stations use 850 shift on H.F.;nearly everybody having switched to 170 shift. If you wish to optimize the ST-5 for 170, you would want to use the following component values:
(ST-5 b.)

170 Shift Values	
R12	6800
R14	6800
R15	100K



ST-5
Fig. 1

Notes

1. All resistors 1/4 W unless otherwise noted.
2. To assist in Tuning Filters, pad locations are provided for Trimming Capacitors C7A, C8A, & C9A.
3. Tuning and equalization of the Discriminator is shown for mark frequency of 2125 Hz and for space frequencies of 2295 & 2975 Hz. To retune for mark = 1275 Hz & space = 1445 & 2125 Hz, change following components:
   R12 - 1.5 k C7 - 0.18
   R14 - 2.2 k C8 - 0.068
   R15 - 8.2 k C9 - 0.068 in par with 0.01
   R22 - 68 k
4. R4, R6, R24, R25, C12, C13 are not assigned.
5. For 100 WPM, change C17 to .039.
6. 709N pin numbers are shown for 14 pin DIP package. For 8 pin TO-5 package, change to:

7. Autostart connections added in February, 1973.
8. For 2550 Hz space tone, change C9 to .033, C9A to .012.

THE POWER SUPPLY

Several transformers are suitable for the loop supply such as the Stancor PA-8421, or the Triad N51-X. Almost any transformer rated for 24 volts C.T. will be suitable for the power supply, if rated at least 200 mills.(The relay will take about 100-150 mills, depending upon brand.)

Hal Communications has a special transformer made exclusively for them by Stancor which combines both the loop and power windings. This saves not only space but money.

CONCLUSION

The St-5 was designed as a simple but highly effective RTTY demodulator using the best of currently available concepts. It should be a very popular unit for some years to come, as it's impossible to imagine at this time how any additional performance could be made available--it's already ridiculous to talk in terms of 90 + dB amplification. Only a completely different concept of RTTY processing could outdate the St-5, and that seems quite unlikely to occur until we all get computer terminals in the shack.

REFERENCES

1. RTTY, November 1964; also QST, August 1965.
2. RTTY Journal, September 1967; also QST, May, June 1969.
3. RTTY Journal, September 1968; also QST, April 1970.

Note: Prices quoted are as of early 1973.

STUNT BOX MODIFICATIONS

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This series of articles will enable you to buy the parts needed to convert a "stunt box" (28KSR) to amateur communications standard, as well as later on, offer various possible stunt box combinations to do various automatic features such as station control, automatic reperf turn-on and turn-off, automatic cr-lf, automatic non-overline, and many other helpful little things which will become more evident as we get into the machine further.

A model 28 is one of the early types of computers. In fact, a Teletype machine itself is actually an early form of computer. The first thing we want to do is change the keypallets and keylevers to communications instead of business type having fractions. This article then will be primarily an "order form" with which you can determine the parts you will need to put the machine into suitable configuration for amateur reception.

Since Bell System machines do not normally need or use auto CR-LF,about 30% of the machines delivered need some major modifications to enable this to be added; the other 60% fortunately need almost no changes at all to the machine itself. In either case, the stunt box needs some parts added.

We suggest first of all you look at the left end of the printing unit, just below the left ribbon spool. See Fig.1--we have tried to show with an arrow (of sorts) where the code bars for the printer stick out the left end. At the right of that housing are numbers for each of the code bars. You will have either 8 or 9 code bars, if you have all 9 including the next to the bottom one marked "0", you are all set and only need the 157514 mod kit to complete the auto CR-LF set-up to the machine proper. If you do not find any code bar there, you will need the 152348 mod. kit.

Now look in Fig.2--this is a photo of the new bellcrank that should be in the machine if it has all 9 code bars. If you are missing the "0" bar, you will most likely not have any bellcrank at this position at all. You can also determine this quickly. If there is no bellcrank, it will be included in the 152348 kit with the "0" code bar, etc.

Fig.3 shows the 157514 mod. kit installed in the bellcrank--this is merely a bracket that attaches through the slot shown in Fig.2 via a bolt just to the left of the slot.

Thus we come to what to order and how to order it.

PARTS NEEDED

If you have the "0" bar and the bellcrank shown in Fig.2, you need the 157614 mod. kit. If you are missing either or both of these items, you will need the 152348 mod. kit.

In any event, you will need all or nearly all of the following items:

GEARS

161293 60-WPM Nylon gear set

AUTO CR-LF

(either the 157514 or 152348 mod. kit, not both), 152671 Function Bar, 152671 Function Bar (total of two needed)

153916 Set of parts for one stunt box slot.

TYPEPALLETS:

157635 Ø (slant zero), 157639 ' (apostrophe), 157640 ; (semi-colon), 157641 : (colon), 157644 ?(question), 157645) (right parenthesis), 157646 ((left parenthesis), 157647 ! (exclamation mark), 157659 # (figures H 'numbers' symbol)

KEYLEVERS

151305 F ! (exclamation mark), 151308 J ' (apostrophe), 151309 K ((left parenthesis), 151310 L) (right parenthesis), 151315 C : (colon), 151316 V ; (semi-colon), 151317 B ? (question mark), 151318 N , (comma), 152009 H # (upper H 'numbers' symbol

EXTRA KEYLEVERS NEEDED OR DESIRED:

151302 P Ø (slant zero), 151322 (blank with no printing, for 'blank')

TYPE PALLET SPRINGS 157238 order 10.

ORDER FROM: Teletype Corporation, 5555 Touhy Avenue, Chicago, IL 60076, Attn: Parts Dept.

You can salvage the springs already in the type-box and use them again, or you can just rip them out and install the new springs, if you order some. Some fellows have already gotten the type-pallets and did not

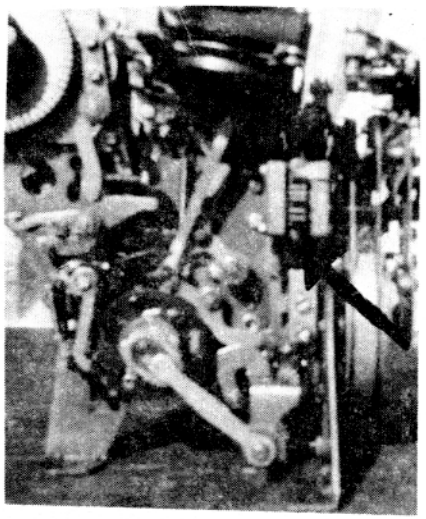


Fig. 1
-- Left end of typing unit (the front part has been removed to show the entire code bar lengths) which shows the ends of the code bars. See Text.

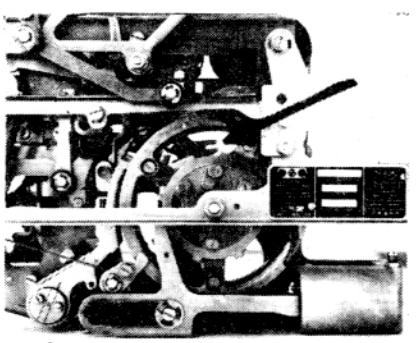


Fig. 2
-- Late-model bell-crank for auto cr-lf. Your machine should have this if it has the "O" code bar, if no "O" code bar, probably no bellcrank either.

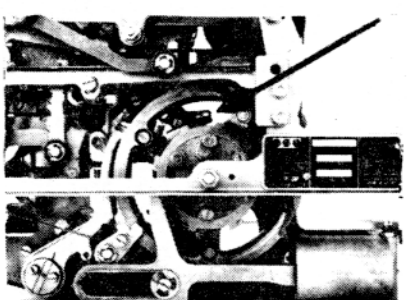


Fig. 3
-- Showing the 157514 mod. kit mounted on the bell-crank of Fig. 2.

order any springs, then found themselves one spring short, for the "figs H" numbers sign (#) which was not in the machine originally. Also you will notice there is already a comma in the type box, but it is over the "J" on upper case. You can later move it over the "N", but do not need to order a new one.

When ordering anything listed in the parts catalog as a "per 100" cost, be certain you include the "per 100" cost and then show you do not want 100, but a fraction of that, and list the price of the quantity you are ordering. If you are not careful, they may think you want say 10 of the item, which comes in 100's in the stock bin, and send you 1,000 total instead of only 10 pieces of the "per 100" items.

There are some Navy manuals that are reputed to be much better than the normal TTY Corp. manuals, and these are also available through the TTY Corp. You would need the parts manual, the adjustments and lubrication manual and perhaps the general theory manual, which is somewhat cheaper. The next article will assume you have gotten the type-pallets and keylevers and will show you how to install those.

HOOKING UP THE MACHINE

You most likely have already discovered how to hook up the machine for use, but at any rate, here we go. There is a 120 VAC plug that goes to the normal wall plug in the building. The other cable has a telephone block type of connection consisting of a (1) green, (2) red and (3) yellow wire. These are connected on the rear terminal strip of the cabinet, which is called the "C" terminal strip. Thus the green wire goes to C-1, the red wire to C-2 and the yellow wire to C-3. The 120 VAC wires go to terminals 39 and 40 at the other end of the same terminal strip, with the third wire grounded to the cabinet itself.

Raising the lid and looking at the service panel to the rear of the printer, you see from left to right the line shunt relay, the mercury-wetted polar relay (type 314A, the 120 DC 3J0 ma. internal loop supply, and the motor-stop relay.

The 314A polar relay is of the pressure-filled, hermetically sealed mercury-wetted type and as such eliminates the objections most of us had to using the older 255A type polar relays. It is our suggestion that you use this relay as it will give excellent results and eliminates the inductive back-e.m.f. normally induced on the demodulator (TU) when the selector magnets go from space back to mark. Among other things, this allows several machines to be used on the same loop without adding distortion, or at least holds it to an insignificant amount.

The line shunt relay serves no important function in a ham station, but since it is already installed it is useful enough to retain. It shorts the "signal line" (incoming loop from the demodular, etc.) out whenever the motor has been turned off manually by the switch to the bottom right of the keyboard, or when the motor has been turned off by the motor-stop relay. This serves one minor advantage and one fairly major advantage. The minor one: The printer stops printing whenever you turn the motor off, and does not print garble while "running down". The major one: If you remove the printer from the cabinet to do any work, it keeps the signal line shorted, thus if you have a second machine on the line, it continues to print normally, rather than "run open" when you disconnect the cable to this printer. One other advantage, if you have several machines on the same signal line loop, it shorts the line whenever the machine is not in use, thus again minimizing any distortion that could be added by the additional machine. These things are all superficial, but of some small interest, and justify in my mind, retaining the line shunt relay.

The motor-stop relay is something else. It's an interesting device and is rigged so that if one types "upper case blank H" it will close temporarily an electrical switch in the stunt box which operates the motor-stop relay, turning off the printer motor and again closing the line shunt relay. As soon as the signal

line is interrupted (as when typing a character), the motor immediately comes back on. Actually, I have heard no valid reason so far for retaining this feature, so most everybody disables the motor shut-off relays. This is extremely easy to do and we'll tell you more about it in a few moments.

So, to hook up the 28DSR to the demodulator's loop supply, just connect the red and green wires to the demodulator. And of course, plug the 120 VAC cable into the wall socket and turn the motor on via the switch to the bottom right of the keyboard. If the printer runs "open" instead of going to mark (and the demodulator is in "standby"), then merely reverse the connections from the demodulator to the red and green wires. This is easier than worrying about plus-and-minus voltages. It either works or they are back wards.

If the motor doesn't even turn on at all under these circumstances, check the fuse on the rear service panel, check to see if the lights for illuminating the copy came on, etc. There is also a tiny red circuit breaker on the motor base, which is literally impossible to see unless you remove the entire base from the cabinet. You can feel it with your finger, it is directly under the motor housing. If the motor still does not turn on, probably one of the wires underneath the service panel is loose, or one of the terminals on the rear "C" terminal strip.

SEPARATING THE KEYBOARD

There are a few people who--for various reasons-- will want to keep the keyboard separate from the rest of the machine. This is so they can drive certain FSK systems directly, or some AFSK systems are set up to be driven directly from the keyboard. A few will want to be able to use the keyboard to drive a reperf while receiving an incoming signal directly from the demodulator. At any rate, here is how you can easily separate the keyboard and bring out its leads independently.

1. disconnect jumper beween C-1 and C-15
2. disconnect jumper between C10 and C-13
3. disconnect jumper between C8 and C-9
4. now place jumper between C-1 and C-8
5. now place jumper between C-8 and C-13
6. You are finished. The keyboard (and break key) is now available at terminals C-9 and C-15. The line shunt relay still is in the circuit.

CHECKING FOR 60 MA.

Nearly all of the 28KRS Mouse machines are wired as received for 60 ma. If you study the schematic included in the "basement" (bottom part of the cabinet) you may conclude the unit is actually wired for 30 ma. or "series configuration". Not so, in most cases. The selector magnets are indeed wired in series internally, but this does not in itself set the criteria for the current in the external signal line. Don't forget that in this unit we are using a polar relay, together with an internal loop supply that is isolated from the signal line by that polar relay. Thus the external signal line requirements have no bearing on how the selector magnets are connected for the internal loop supply.

You can easily check to see what configuration you have, but it requires you to remove the printer and keyboard base first. This is simple to do. First you remove the little piece that runs directly above the keyboard. There are thumb screws on the inside of the cabinet at either end of the keyboard to make removal of this piece easy.

Then on the keyboard base proper, there are four large bolts to remove, one at the extreme edge of each of the four corners. These bolts are about three inches long, or so, and go through the top of the keyboard chassis down to the cross pieces holding the unit to the deck of the cabinet. Remove these four bolts, unhook the cable to the right side of the printer unit, and lift the entire works out of the machine. The rear service panel of course still remains in the cabinet. Now at the left extreme end and at the right extreme end of the service panel you will notice similar long bolts holding the service panel to the deck of the cabinet. Remove these two bolts. Now pull out the on-off switch that goes from the front of the cabinet back to the service panel. This rod just "hooks" into the hole, so try to center it exactly in the hole by pushing down slightly, and then it will pull right out.

Now turn the service panel upside down. You will see numerous terminal strips underneath, all of which start numbering at the rear and come toward the front.

The terminal strip at the left end is the "A" strip, beside it is the "B" strip. (The "C" strip is at the rear of the chassis itself). The "J" strip is on the bottom of the polar relay, the "D" strip is the second from the right, and the "E" strip is the final one on the right. Again notice carefully how they are numbered, as they will start from the front, and it's easy to count wrong if you don't look carefully for the numbers on the strips themselves.

For an external loop of 60 ma., the following should be jumpered: D4 to D5, D5 to D7, and D7 to D6. Over on the "J" strip, you would have JI-1 to JI-2. (The instruction book also mentions K1 to K2, don't waste your time looking for this connection, it is only in machines having a line test key, which none of these have.

While looking down there, if you do insist on bypassing the polar relay, and wish to get in on the selector magnets directly for 60 ma. here is how to do that. Most of you will wish to ignore this paragraph however:

1. Remove any jumpers between A-1 and A-2
2. Jumper A-1 to A-4 instead
3. There are two brown wires on A-3. Remove the left one (it goes to one of the selector magnets, the other brown wire goes to a 600 ohm resistor on the polar relay base) and hook it on A-2. You can verify you have the correct brown wire by hooking an ohmmeter between it and the brown wire

on the left selector magnet on the printer, although this first requires you to place the connector back on the printer, which may be awkward to accomplish at this time. It also normally has a hole in the connector, while the "wrong one" normally has only a spade lug on the end.

4. Put a jumper between A-2 and B-5. This B-5 has a white wire on it which goes to C-4 on the rear terminal strip in the back of the cabinet.
5. You are finished with the power supply panel, so replace it in the cabinet, hook up the on-off switch, and replace the keyboard base,printer etc. Reconnect the cables to the printer and keyboard.
6. On the rear terminal, remove the jumper between C-20 and C-21.
7. You are now completely finished. The selector magnets are now available at terminals C-4 and C-20.

There is no need to change any other wires on the bottom of the service panel. By the way, that is called the "LESU" portion of the printer. The printer is called the "LP" and the keyboard is the "LAK". The cabinet is usually called the "LAAC".

So if you use the polar relay, and the connections we mentioned to check on terminal strips "J" and "D", you will then use a 60 ma. external loop to the red and green wires. The selector magnets will actually be hooked internally for series configuration of the internal loop. If you decide to bring them out directly, they will then be in parallel for 60 ma. operation.

Up to this point, we have discussed what parts you would want to order, what manuals you might wish to obtain, how to hook up the machine to use it and how to bring out the keyboard and/or selector magnets directly if desired.

INSTALLING THE KEYPALLETS

The first thing to do is to remove the "type-box". This is the black rectangular object about 2" long and 3/4" high that sits directly in front of the platen. As you strike various keys, the type hammer hits various small projections sticking out of this unit, causing them to be knocked forward against the inked ribbon and making an impression on the paper.

This type-box is quite easily removed. Just to the right end, you will see a light-colored retaining clamp that is curved. At the top of this curved piece is a small lever. Just take your finger and push this lever to the right, and the curved piece will move away, allowing the type-box to be lifted out readily. At this time, note that end of the type-box with the hook on it goes to the left, and the long stud is on the right end.

Now remove the bolts from either end of the type-box and pry the two peices apart. The unit that faces the type-hammer will look like a screen with a lot of holes in it. Lay this aside until finished putting in the new typepallets.

From here, you will want a tiny screwdriver, a bright light, and if over 35 years of age, no doubt a magnifying glass of some sort that may be positioned without having to hold it manually (as you will need both hands free.) In my case, I found a nice pair of magnifying glasses at the local dime store for elderly people with poor eyesight, for around $2 that surely simplified this and many other jobs where you deal with small objects. (Stunt box parts, springs, etc.)

If you have the new typepallets and springs we mentioned ordering, you will probably see how the typepallet first is inserted through the screen that is closest to the ribbon, and then a spring is slipped over the typepallet so the end with the hook will engage the slot in the typepallet. If trying to use the original spring while exchanging the typepallet, this is entirely possible, but may be somewhat frustrating to disengage the hooked end so the spring may be lifted off the "old" typepallet. A small screwdriver can usually be manipulated so the spring may be removed satisfactorily, and you may even enjoy doing this rather than just ripping it off and replacing with a new spring.

Since on the original type-box there were two "0" typepallets and no "Ø", you will need to know where to put your new "Slant zero" typepallet. It goes beside the "8". The "comma" goes on the top row beside the "period", and the "#" (figs h number sign) goes beside the "comma", then.

I do not have any good pictures of the rear of the type-box, but here is a rundown on what mine now has in it:

Top row, left-to-right -- 9 (blank) 5 (blank) (blank) # ,.0 (blank) T (blank) (blank) H N M

2nd row: ? $ " 3 (blank) 6 ! B D Z E S Y F X

3rd row: & 4) (blank) 8 Ø : ; G R L (blank) I P C V

4th row: (blank) ' 2 - 7 1 (blank) (blank) J W A U Q K

In putting the two pieces back together, just hold them tightly at each end and move back and forth while many of the typepallets will pop through the rear screen. Then, while still holding one end tightly, take your other hand and wiggle the ones that would not pop through by themselves until they do come through. It's not a hard job at all and in no time they will all be properly positioned and the two ends can be bolted back together once more. Remember that the heads of the bolts are on the "ribbon side" and the nuts are on the "type-hammer" side, with the long one being on the right end, as viewed from the "type-hammer" side.

ADJUSTING THE TYPE-BOX

You will probably have no occasion to want to adjust the type-box at all, but you may wish to know how it is accomplished. When you had the type-box out of the printer, you probably noticed a small halfround tab right in the middle of the bottom. Directly ahead of this tab, in the typing unit itself, is a small bolt with a screw head and retaining nut to hold it in place. This bolt pivots the type-box slightly one way or the other so that the top and bottom parts of each character will be uniformly impressed on the paper.Thus if it appears you have normal appearing print, forget about this adjustment, but if all your letters seem

to be darker at the top than at the bottom, or opposite, then adjusting this little bolt should cure the problem.

INSTALLING THE KEYLEVERS

The easiest way to install the new keylevers is to take the entire keyboard base out of the cabinet. You may leave the printer unit on the base, although it would probably be easier to carry the base around if the printer unit were first taken off the base. Since we have not previously discussed to any extent how to do this, a quick review might be helpful.

TAKING THE TYPING UNIT OFF THE BASE

First of all, unplug the cable at the rear of the right-hand ribbon spool. Then you remove four rather large bolts that hold the printer to the keyboard base. There is one on each corner. (1) Left-front, almost directly below the left edge of the left ribbon spool, (2) Right-front, directly behind the right-hand edge of the "dashpot" cylinder. (3) Left-rear, directly under the left end of the paper spool's center and (4) Right-rear, almost directly under the right end of the motor cooling fan and slightly in front of it.

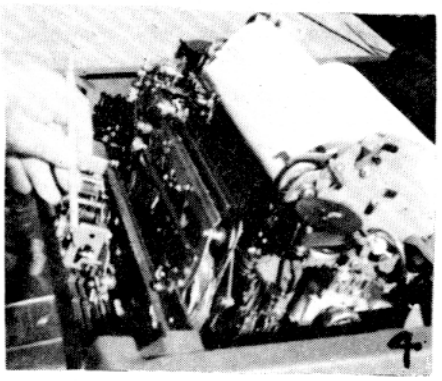
Lift the typing unit off the base and place on a spread-out newspaper someplace as the bottom will be oily.

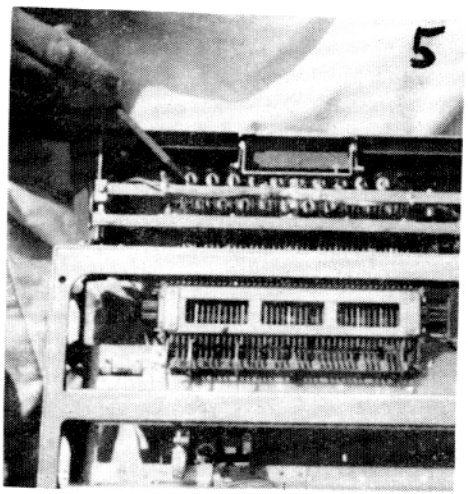
TAKING THE BASE OUT OF THE CABINET

Disconnect the cable at the left rear, take out the four bolts at the corners, remove the small green part of the cabinet directly above the top edge of the keyboard (held in place by a large thumbscrew at either end that you loosened inside the cabinet to either side of the keyboard) and then the entire keyboard and base (with motor, etc.) may be taken easily out of the cabinet.

Set it on a piece of paper on a table or workbench in a flat position. To either side of the keyboard will be a plastic plate under which information is usually placed regarding who to call if trouble exists, or whatever information the company or operator has thought necessary to have available. Anyway, remove those plastic plates, and the papers that are beneath them. Now you will see some other bolts that hold the cover plate around the edge of the keyboard. Remove those bolts. The cover will not as yet come off.

Now set the base on end with the keyboard in the air so that you are looking at the bottom side of the base. You now should see the remaining bolts that hold the wraparound plastic cover around the keyboard, there should be a bolt at each end of this cover.





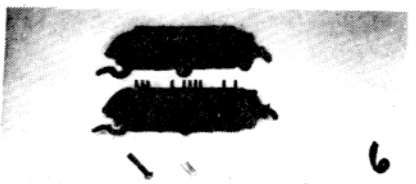


Fig. 4 - Keyboard reset bail
Fig. 5 - Under-side of keyboard with wrap-around cover removed.
Fig. 6 - Type-box taken apart, showing one typepallet and spring.

Take the cover off, and you will now see the underside of the keyboard proper. Before going any further, get out one of the new keylevers, such as the "B ?" one. Note how the bottom end has two projections with a slot between, and near the very end the slot becomes round. It is this round part that grips the pivot point on the keyboard lever. Find a screwdriver whose blade width is such that without undue work, can be used to slightly separate the two projections when the screwdriver is inserted in the slot and twisted a bit for prying purposes.

Now start with something like the "Z" character. Depress the key, and you should hear it go "clunk" and stay down. If you cannot see on the bottom of the keyboard where this one is now a little lower than the rest, wiggle the "Z" key somewhat until you see where it is, on the bottom. Insert the screwdriver above the pivot point, in the "slot" and twist slightly and just push the screwdriver straight up toward the keyboard while twisting - the keylever comes right off with a minimum of effort. The new one then just snaps into place.

When finished with the "Z", and going on to whatever is next, you will find the "Z" has remained down, and you cannot push any others down. You merely need to take your hand and reset the keyboard bail, which brings the depressed keylever back up and allows you to depress another. See Fig.4--you just push the bottom of this bail plate to the left to reset it.

Fig. 5 shows the bottom of the keyboard with the screwdriver in the slot above one of the keylever pivot points, but does not show up as well as we hoped it would.

At any rate, replacing the keylevers is not at all difficult and in fact rather enjoyable. We have to assume that anybody interested in RTTY probably already has some interest in mechanical objects and not completely without at least a little talent in wielding a few basic tools. Not to slight anybody's ability, but with these instructions, a typical high school boy should be able to per-

form any of the tasks outlined so far or planned in the future.

After finished with the keylevers, just replace the wrap-around cover, the bolts under the plastic cover plates, then the papers and cover plates themselves, put the keyboard base back in the cabinet, reconnect the cable, put the typing unit back on the base, replace its connector, and put the bolts back.PRIOR TO PUTTING THE BOLTS IN HOWEVER, ROTATE THE MOTOR BY HAND (COUNTER-CLOCKWISE AS VIEWED FROM THE RIGHT SIDE OF THE CABINET) TO MAKE SURE THE GEARS ARE ENGAGED PROPERLY.

You should now be finished with the keypallets and keylevers.

DISABLING THE MOTOR-STOP RELAY

All "mouse" machines have a motor-stop relay so that on a given sequence of characters, the motor will automatically turn off. It comes on again as soon as anybody sends a character or otherwise causes the line to open. For amateur purposes this motor-stop relay has little or no practical use in "as is" condition. We do not recommend taking it out of the printer but you may wish to disable it for the time being.

On the "repaired" mouse machines, the motor turns off if anybody sends "upper-case blank H". (This is similar to, but not necessarily the same as FIGS BLANK H). On some of the "non-repaired" machines,this sequence was "upper-case blank Z".

If you remove the roll of paper so you can look at the top of the "stunt box" you will see (slightly to the left of the center) a tan-colored (or brown) plastic piece with some wires running to it. If you now turn the motor on and type "figs S", the bell should ring, and you should see some modest mechanical action near the left front edge of that plastic block each time you subsequently type another upper-case "S". Just to the right of the slot which jumps during an upper-case "S" is the slot that operates the switch adjacent to the switch for the bell. That adjacent switch momentarily completes a circuit if an "upper-case blank H" is typed (or "upper-case Z" on some machines) which pulls the motor-stop relay to the "stop" position.

Just to the rear of that switch is a black projection sticking out of the rear of the stunt box. This is the "function pawl". It has a hook-type end on it. If you want to easily disable the motor-stop from working, all that is needed is to lift up the rear of that black function pawl and keep it lifted. This can be done in a variety of ways, but for now let's just say that the easiest way is to slip a small wire (or string) under the hook on the function pawl and tie to the channel bracket above that has the wires in it that go to the switch. By tying the pawl up, the function lever cannot engage the function pawl, which in turn will not operate the function lever which would normally then operate the switch. This is getting a little ahead of the story for the next article, however, which should explain more about the stunt box.

THE STUNT BOX

This is possibly the section that a great many of you have been waiting for. There is so much to cover, however, that we shall have to do it in bits and pieces.

If you have wondered why this unit is called the "stunt box", you will better understand after we have shown you how to remove it. Since this mechanical marvel enables the operator to accomplish a great variety of features (or "stunts"), it became known as the "stunt box". An excellent booklet going into elementary detail of the stunt box was available for free from the Teletype Corporation until recently, but unfortunately they no longer print the booklet. We shall therefore, have to try to describe the action of the various parts through a few simple photographs. The 216B manual on "Description and Principles of Operation" has some modest but informative drawings of the stunt box in Section 573-115-100 on pages 33-37.

It would probably be easier to discuss the stunt box and components in it if we were to first have a look at it.

REMOVING THE STUNT BOX

The stunt box is located at the rear of the typing unit, directly below where the roll of paper sits. Fig.7 shows the unit removed, just as it would be pulled out of the machine, with the rear part facing you, as well as the rear of the typing unit. Fig.8 is approximately the same thing, but with the stunt box swung around to show the "business end" that plugs into the typing unit.Fig.9 probably is a poor photograph, but shows the stunt box in my particular 28ASR, which is "loaded" and has all 42 slots being used for various purposes. This is getting ahead of the story, but Figs.8 and 9 show the two extremes between a "minimum loading" and a "full house" loading.

Now to get on with taking it out of the machine as shown in Figs.7 and 8. First, remove the typing unit from the keyboard base. We have discussed this before, if you need a review, see the article where we were talking about the keylevers--under that section we discussed removing the typing unit.

Set the typing unit on a piece of newspaper, then turn it around so the rear faces you. Remove the paper roll if you have not already done so.About the bottom of where the paper had been, you will see (on most of the machines, probably all of them)a six-sided rod about the size of a wooden pencil that runs between the left and right frame members (that supported the paper roll.) There is a bolt on each end holding this rod to those frame members. Get a small bowl or box to put these parts in, otherwise you'll surely knock them on the floor sooner-or-later and perhaps lose them. Remove the bolt at either end of that rod, then pull the rod out and lay aside.

Now looking slightly ahead of where this rod was, we see another one, only this one is round and smaller in diameter--about an inch ahead of the one we just removed. This rod is part of the stunt box (operates the "stripperblade") and will not be removed, but there are some things attached to it which have to be disconnected. At the left end of this

rod, about one and three quarters inches from the left frame, there is a connection to this rod that goes to the main shaft below and operates the rod as the motor turns the gears. There is a bolt and retaining ring ("C" ring) that holds the piece to the shift. Remove the ring and the bolt. Now the rod is free from the coupling, which may be pushed to one side to disengage it from the arm that goes to the main shaft--this arm then will drop down out of the way (depending upon whether the main shaft below has been rotated far enough).

Directly ahead of this rod we have been working on is the "stripper blade". It looks a little like a household "ruler" that you use to measure lengths up to one foot. About one-half inch from the right side you will see a piece that has been added to the stripper blade. This "strips off" the pawl on the line feed slot. Look at the bottom of that added piece and you will see a hook that engages a small lever that projects through the hook. Keep this in mind, as this hook can get caught when trying to remove the stunt box (or replace it) unless you first lift it up with respect to the stripper blade; also when replacing the stunt box it is imperative that it re-engage the lever again.

Now just below the stripper blade at each end you will see two bolts. At each end, one of the two will be lower and farther away from the center of the machine than the other. It is this "lower" bolt at each end that holds the stunt box in the machine. Remove this "lower" bolt from each side, and now the stunt box is ready to be pulled out. Before you do so, note that the electrical wiring along the top of the stunt box is held from getting in the road of the paper by a small metal arm along the left frame member. Loosen that arm, swing it down a bit, free the electrical wires, and then put the arm back where it was. Now pull the stunt box out. When you have removed the two "lower" bolts, usually the stunt box "pops out" about a quarter-inch from the spring tension on the function bars. If it has not already "popped free", tug a little at either end of the rod ahead of the stripper blade, or rotate the main shaft below a revolution.

You can now slide the stunt box out, noting that it has grooves at either end to assist in this. At the right end, make sure that little "added piece" on the stripper blade is high enough to clear the bracket where you removed that "lower" bolt, otherwise you will be unable to pull it out any further. You will also perhaps need to rotate the main shaft somewhat so that the arm that hooked to the rod clears the bottom of the stunt box.

Although this has been quite detailed in an unscientific manner, you will appreciate these hints for the first attempt. After that of course, it immediately becomes a very simple job. Those reading this information who have already removed the stunt box a few times will find this section too elementary to be of any interest. But when working with a machine whose new cost was around $1,200, a person finds even the most simple detail of great interest.

The end of the stunt box that has the electrical wires connected is the "beginning" end, and the slots are numbered starting at this end.

TYPICAL SLOTS

The "repaired" mouse machines should all have a common stunt box arrangement. I think the non-repaired will all be identical except for a "Z" instead of an "H" on the motor-stop set-up as discussed in previous paragraphs.

Slot 1 - "Space"
Slot 2 - "Figures"
Slot 3 - "Letters"
Slot 5 - "Carriage Return"
Slot 22 - "Blank"
Slot 28 - "Blank", upper-case"
Slot 29 - "H, upper-case"
Slot 30 - "S,upper-case print-only"
Slot 35 - "Blank"
Slot 36 - "Blank"
Slot 38 - "Line Feed"
Slot 40 - "Line Feed, print-only"

Now to explain. Slot 1 (space) is the "downshift-on-space" system. When a space is typed, it will pull a "shift-fork" on the top part of the stunt box which in turn operates the bottom code bar and puts you back into lower-case, if you were in upper-case. All the mouse machines have this feature. About the middle of the top part of the stunt box at slot one is a bolt and locking nut. If this bolt is run "down" into the top of the stunt box, it causes the front of the function pawl in slot 1 to tilt down, causing the rear part to raise (front in this case being toward the "business end" of the stunt box, rear being toward the stripper blade and rod.) If the function pawl is raised, it disables the "downshift-on-space" feature. Under rare circumstances you may want to disable this feature, as for copying certain commercial stations, but in general it is a most valuable feature and you would want to run the bolt out to where it does not interfere with the operation of the function pawl.

Slot 2 operates a slide on the top which pulls the shift fork the other way, causing the bottom code bar to go to "upper-case" and slot 2 also suppresses spacing during operation of "Figures" characters. Slot 3 pulls the same lever that slot 1 can operate, and moves the shift fork to "lower-case". Slot 3 also suppresses spacing.

Slot 5 operates a slide on the main frame of the typing unit just below the stunt box, which mechanically trips the carriage return mechanism. It also suppresses spacing.

Slot 22 has only one purpose, it suppresses spacing on "blank" characters, or during "open loop" configuration as when holding the "break key" down.

Slots 28 and 29 work together. If you get an "upper-case blank" slot 28 works, and latches up for one slot, so if immediately followed by an "H" (or "2" on some machines) it will then complete the switch above slot 29 and this will activate the "motor-stop" relay. Slots 28 and 29 are called "sequential" since 29 cannot work unless 28 has been selected immediately prior.

Slot 30 is the "bell" and works from an "upper-case S". The bar is

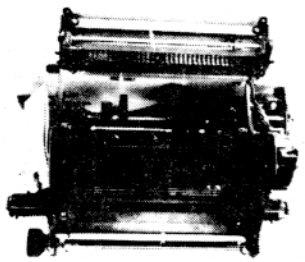


Fig. 7 Showing a stunt box as pulled out of the rear of the typing unit.

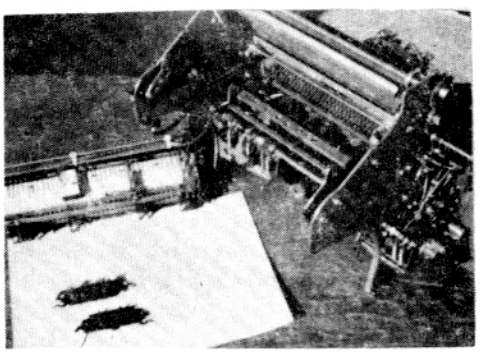


Fig. 8 Same stunt box showing the front side. The function bars are visible sticking out the front plate.

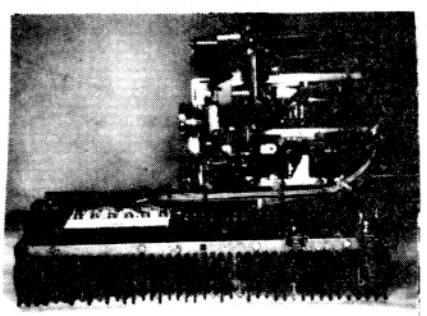


Fig. 9 A completely "loaded" stunt box using all 42 slots as used at W6FFC in the main 28ASR.

also coded for "print only" which has to do with selective call-up (Selcal) so the bell won't ring if you are in "non-print".

Slots 35 and 36 are also "sequential" so if you get two consecutive "blank" characters (or an open circuit) it will activate a slide on the main frame under the stunt box and mechanically lock the keyboard so you cannot type on it. This feature is of no particular value on radio circuits and may be disabled by tying up the function pawl on slot 35. This was discussed relative to the "motor stop" on slots 28 and 29. For simplification we suggest tying up the function pawl "in the slot adjacent to the bell slot". That would be slot 29. However, now that you understand a "sequential pair of slots, you will see it would actually give less wear and tear if you prevented the first slot from working rather than the slot that actually performs the function. We'll recommend you thus tie up slots 28 and 35 to prevent motor-stop and keyboard lock.

TYING UP FUNCTION PAWLS

This was discussed under "motor stop". We suggest if any of the pawls are now tied up (or if you are using an intentionally disabled downshift-on-space system in slot 1, you temporarily now put these slots back to normal. Here's the reason. When the function pawls are tied up, the function bars are free to slip out of the stunt box if it is tilted, and in any event, the springs on the function bars will attempt to pull them out of the box. This makes it very awkward to replace the stunt box properly, even when you know what you are doing. By lowering the function pawls to normal position on such slots as 1, 28, 29, 35, and 36, then the function bars associated with those slots will be kept from slipping out of position, and returning the stunt box to the typing unit will be a simple job. Otherwise, even experts would have a most difficult problem without using special tricks of some sort. Those slots are easily enough tied back up to their "inactive" position once you get the stunt box back in the typing unit. This is a most important and useful hint, so do not overlook it! You will also find on many machines a small bracket on the top of the stunt box adjacent to slots 28 (may be partially hidden by the switch block) and 35.These little metal brackets are for the purpose of holding up the function pawl automatically. I suggest you do not use them, but instead just "tie up" the function paw via a piece of string or small wire to the channel iron that holds the electrical wires. There are also special clips for the purpose which resemble bent paper clips.

THE REMAINING SLOTS

We had two slots to go before getting side-tracked about the sequential slots. Slot 38 has a "line feed" function bar in it whose only purpose is to suppress spacing for a line feed character. Slot 40 has a "line feed" function bar also, but responds only during "print". This is for "Selcal" action so that if in "non-print" you do not turn up a new line feed each time one is called for.

You will probably wonder why it is not possible to suppress spacing with slot 40 instead of having to add slot 38 for that purpose. It's a very interesting situation. Slot 40 actually operates the slide which trips off the line feed clutch. This is a "3-stop" clutch. That is, it COULD BE operated 3 times while the others are operated once. (The "spacing clutch" is also a 3-stop; all the others are "1-stop".

The reason the line feed clutch is a "3-stop" is to enable it to turn up two lines if desired rather than one. Many commercial installations such as radio stations, TV news departments, etc. prefer to double-space all incoming text automatically. The function pawl on the slot 40 is tripped off not by the main stripper blade but by the "added piece" we mentioned previously, so that it could be operated several times for double line-feeds. Anyway, to insure proper spacing suppression for line feed, we do it in "some other slot", namely slot 38 in this case.

REQUIRED SLOTS

Assuming you want to later add "auto CR-LF", we must use seven specific slots and 2-3 others of those remaining.

Slot 1 - Space--for downshift on space
Slot 2 - Figures--for upper-case
Slot 3 - Letters--for lower-case
Slot 4 - Auto CR
Slot 5 - Carriage Return
Slot 39 - Auto LF
Slot 40 - Line Feed
Slot "A" Bell--upper-case S
Slot "B" Suppress spacing for line

feed
Slot "C" Suppress spacing for blank

Thus we have pretty much committed 10 of the 42 slots. This leaves 32 more that you can do all sorts of fancy things with, such as "Selcal", excess line feed prevention, excess bell-ringing prevention, automatic station control, remote control, automatic T.D. control, have it ring a bell in the house or shack if somebody mentions your name or call letters, have it ring a bell if somebody unexpectedly sends "BK", and many other things which you may wish to do. Now let's show you how to install "non-overline" in your machine in a few seconds and at no expense.

ADDING NON-OVERLINE

On a "normal" Teletype machine, if someone accidentally hits the "Carriage Return" character, of course the carriage comes back, but will not turn up a new line. Thus, it is easily possible to retype over the same material a second(or more)times. This is called overlining, and of course is more than slightly annoying, as it not only wires out what you have printed previously, but also destroys what is now being printed.

Fortunately, the 28-series of Teletype equipment adapts immediately to "non-overline protection", and without use of new parts. The system requires almost no effort to incorporate and can be changed back in few seconds to "factory stock" anytime the stunt box is removed from the typing unit.

In the case of the "mouse" machines, merely exchange the function bars in slots 5 and 38. That's absolutely all there is to it! The function bar is the item with the various "teeth" (tynes) that sticks out the front (business end) of the stunt box. To remove a function bar, unhook the spring on the bottom side of the stunt box, and merely pull the function bar out. It will probably catch on the hook of the function pawl at the rear of the stunt box, in this case, merely take your finger and hold up the function pawl for that particular slot and at the same time pull the function bar out.

If you are reading this series of articles and do not have a "mouse" machine, it is simple enough to find the proper function bars. Prior to removing the stunt box, do this:

1. Remove the roll of paper.
2. With the motor running, peer at the top of the stunt box.
3. Hit the "carriage return" key--some slot should show activity--probably slot 5, starting your count at the right end of the stunt box as you look in while standing in front of the machine.
   Remember this slot number.
4. Now hit the "line feed" key. Two slots should show some activity. Slot 40 no doubt, and some other slot somewhere, probably (but not necessarily) slot 38.
5. Leave slot 40 alone, but exchange the other two you found and replace the stunt box.

WHY NON-OVERLINE WORKS

We have now placed a "line feed" function bar in slot 5. This also suppresses spacing for line feed characters. We have now put the original "carriage return" function bar in the "other slot". Thus all it now does is suppress spacing for "carriage return" characters.

Thus when a "carriage return" character is typed or received, nothing at all happens, and the carriage really does not come back at all, like it once did. On the other hand, now when a "line feed" character is received or typed, this will return the carriage via slot 5 and turn up a new line via slot 40. Thus we have eliminated the possibility of an erroneous carriage return wiping out previous material via "over-lining", and now the machine acts more like a normal typewriter insofar as we get carriage return and line feed concurrently.

The 28 machine gets back so rapidly to the beginning of a line it is not necessary to type some "non-printing" character (such as a "letters") following the line feed, but it is still standard practice and always has been. Even at 100 speed, the unit should "get back in time" if properly adjusted. Perhaps normal "end-of-line" sequence should be reviewd as many people apparently are not aware of customary routine in this respect:

1. CR
2. CR
3. LF
4. LTRS

It may feel awkward for a while to hit the "CR" key and have nothing at all happen, but the delightful improvement in copy will make it most worthwhile.

Before leaving the subject of non-overline, let me say that there are many other systems which you can use as well. It should be obvious that none of them could approach the simplicity of this system where you merely exchange two items in the stunt box that are easy to get at. The other systems require moderately elaborate slot components, some special parts, and rely completely for normal operation upon the reception of "CR" and "LF" in their proper sequence. Some of these systems are fascinating to install or decipher, but in genral you would find them costly, inferior in performance to this ultra-simple system, and worst of all, they tie up several slots you may need for other things.

REPLACING THE STUNT BOX

If you now have the "non-overline" feature added (or for some reason decided you didn't have any need for it) you are ready to replace the stunt box. We have not installed "auto CR-LF" parts as yet, we'll get into that a little later in the series as right now we are trying to give you the "feel" of the stunt box and don't want to rush things too fast.

Make sure none of the function pawls are tied up or held up via the little metal brackets we talked about. Peer under the stunt box and make certain all the springs are hooked properly to the function bars. Now note that on either side of the stunt box is a little guide to go in the "rails" to help put it back in the

typing unit. There are only three things to particularly watch as you slide it back in:

1) The "arm" from the main shaft below might get in the way of the leading edge of the stunt box, so be careful to keep it out of the way.

2) As you get a little further in, make sure the hook on the bottom of the "added piece" of the stripper blade clears the bracket that holds the right side of the stunt box, and then as you get further in, make sure this hook engages its lever properly.

3) The "shift fork" at the top left of the stunt box (we are at the rear of the unit, and "left" corresponds with slot 1, etc.) must engage the shaft in the typing unit properly. You may take a screwdriver and tap the "U" slot in the shift fork so it will properly engage, if necessary.

When you get within a quarter-inch or so of all the way in, you will meet sudden resistance. This is normal, as the function bars are spring-loaded and resist this final short distance. If everything else appears normal, just give a quick push at each end of the stunt box and it should snap into place. It may be necessary to hold it there while you install the two "lower" bolts to hold it in place.

Then hook up the main shaft "arm" to the coupler on the rod at the rear of the stunt box and install the locking bolt and "C" retaining ring again. Put the electrical wires under the little metal arm to keep them out of the way of the paper roll. re-install the support bracket (the six-sided rod), put the printer unit back on the keyboard base, turn the motor by hand (CCW) 1-2 revolutions, replace the four bolts holding it to the base, reconnect the cable to the rear of the right ribbon spool and you should be back to normal after re-tying up the function pawls for keyboard lock (slot 35) and motor-stop (28 or 29). You will now have non-overline and have learned quite a bit about the stunt box in the process. Now you will be anxious to add auto CR-LF, and that will come soon.

In the previous paragraph we explained how to remove the stunt box from the typing unit, how to convert it easily for automatic "non-overline" and how to replace it in the typing unit again.

There are a great many special features available for the 28 printers that are of no particular interest to RTTY enthusiasts, such as form feed-out, reverse line feed-out, tabulation stops, sprocket feed, on-line reverse, etc. So keep in mind that as we explain "what is available" we are concentrating on those things of particular interest to RTTY operators.

There are 42 slots in the stunt box for various combinations of components. Viewed from the rear of the printer, these are numbered from left to right. We have discussed many of the important slots and their mandatory use, so you will perhaps wish to review that section once more.

Under slots 4 and 5 is a slide (mounted on the main frame of the typing unit) that when pushed toward the front of the machine releases the carriage so it may return to the left margin stop. Another similar slide is under slots 36 and 37, and when pushed forward will lock the keyboard so the operator can no longer type. (This feature has little or no particular value to amateurs--it was used to lock the keyboard for two consecutive "blanks" so that on land-line circuits, depressing the "break key" would lock up any keyboards being used at that instant for a priority message, or for repeats, etc. For a RTTY radio circuit, it is much more of a nuisance than any advantage.)

Under slots 30 and 40 is yet another slide, this one operates the line feed clutch.

The important thing to remember on any of these slides is that they may be operated by ANY function bar placed in one of the slots, regardless of what it is coded for. That is, we could put a "M" function bar in slot 40, for instance, and get a line feed each time the "M" character came along. Of course we would never get any line feeds for a normal "line feed" character then, unless we put it in slot 30, for instance.

Thus in the simple conversion to automatic non-line, we removed the normal "carriage return" function bar from slot 5 and instead put in a "line feed" function bar--now the carriage comes back on a "line feed" character. Since a "line feed" function bar remained in slot 40, both actions occur simultaneously, making it impossible to get accidental carriage return action without turning up a new line at the same time.

WHAT IS IN A SLOT ?

Fig. 10 shows the typical parts in a slot. The slender item at the top is the "function pawl". The vertical piece is called the "function lever" and the small item to its left is the "spring plate". To the right of the function lever are three springs. The one item between the springs and the large function bar is a cotton wick that slips into the spring for the function pawl. This spring is immediately recognized as it is canted at one end, although this hardly shows up in the photograph. The longest spring of the three (middle one) is for the functin bar, the shortest is for the function lever and spring plate.

HOW DO THEY WORK?

This is rather difficult to show. Teletype Corp. had a marvelous booklet available with colored drawings showing the operation of the various components. Unfortunately this is no longer available so, perhaps you can tell, to some extent, from Fig.11 and 12 what is going on, and then later on when you install the parts for auto CR-LF you will be able to better see what is happening.

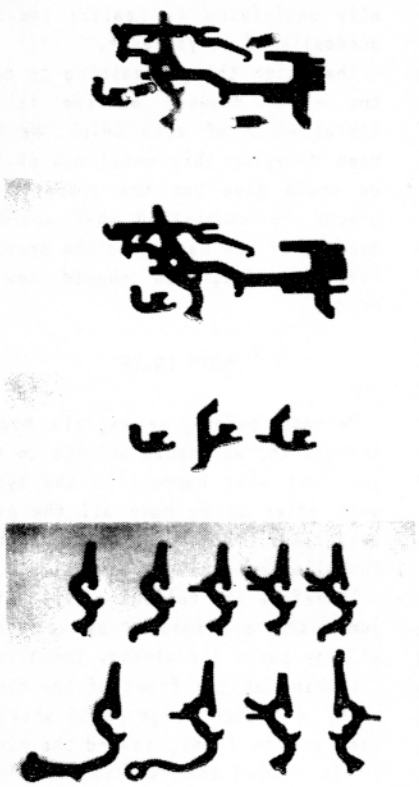


Fig. 10 Various components in each stunt box slot that is in use

Fig. 11 Showing stunt box components in approximately their "idling" position

Fig. 12 Showing stunt box components in approximately their "being used" position.

Fig. 13 Types of latches

Fig. 14 Typical types of function levers.

Fig.11 shows the components mounted approximately as they would be in the slot in the stunt box.It shows everything "at rest". Fig.12 then shows what happens next. If the proper code bars are moved in the typing unit, then the function bar can jump forward (toward the keyboard), its rear projection no longer is in the way of the rear of the function pawl which then due to spring pressure falls down. Now as the motion of the typing unit continues, the bail reset pushes the bottom of the function bar to the rear, resetting it. However, the rear of the function bar is now caught on the rear of the function pawl which has fallen down so as the function bar is moved back, the function pawl goes with it. On the side of the function pawl, about in its middle is a projection off to its left side. As the function pawl is pushed to the rear, this projection knocks into the function lever near the top of the function lever, and causing it to tilt toward the rear. As the function lever tilts, it may accomplish various things either with the very top, with the middle or with the bottom--we'll go into that in a moment. The function lever will remain tilted (for about 54 milliseconds at 60 speed) until the "stripper blade" at the rear of the stunt box raises and lifts the rear of the function lever high enough to clear the rear of the function bar, allowing the function pawl to return to its normal position. This in turn allows the function lever to return to normal.

The only purpose of the "spring plate" is to anchor the spring for the function lever to enable it to return to its normal place.

There are some rods running the length of the stunt box to keep things in their proper position, once installed. That is not too important now.

LATCHES

Fig.13 shows three items:

1. 152660 Spring Plate
2. 152089 Latch, released by stud or rod only
3. 154613 Latch, released by stripper blade on next character.

It is the no.3 type latch that is used for "sequential" operation. The no.2 type latch is used where you wish to keep a function lever latched down indefinitely so it can keep a switch open or a slide in position etc. (as for "Selcal" and other purposes.)

FUNCTION LEVERS

There are many different types of function levers. Twenty-seven types are shown in the current parts catalog 1149B for the 28KSR. (Section 573-115-800TC, page 61). We have attempted to show most of the more useful ones in Fig.14: (From left to right in the top row and then left to right on the bottom row).

1. 152642--may operate a slide
2. 152641--may operate a slide and suppresses spacing
3. 152298--may operate a slide and may be latched down
4. 15212--may operate a slide, may be latched down, and prevents the adjacent slot from operating until this lever is first latched down. (The adjacent slot has to be to the left of this function lever, called a "next higher numbered slot"--these levers are called "sequential" by some people to simplify their purpose)
5. 152659--similar to no.4, but also suppresses spacing
6. 154647--suppresses spacing, holds a stud (as shown) or may hold a rod
7. 153670--may be latched, holds a stud or rod
8. 157207--may operate a slide, sequential, has a short top
9. 163943--may operate a slide, may be latched, and has a special top with a stud to the left which will operate two electrical switches at the same time. (Must be used with a function lever with a short top in the next higher-numbered slot).

There are a great many more, but these show nearly all the special features that are available.They will give you an idea of some of the things that may be accomplished, later.

FUNCTION BARS

There are well over 264 different combinations available if my mathematics are correct. Consequently we have not bothered showing any of these other than in Fig.10.The 153440 "uncoded" (universal) function bar has some 16 tynes on it originally. There is a left row of 8 and a right row of 8. The end of the code bar housing tells what they are for if you want to look at your machine. The top one is for print or non-print, the next five are the "information" tynes for the various characters, the next to the bottom is the "Zero level" used by RTTY enthusiasts only

for auto CR-LF normally, and the bottom ones are for upper-case (Figs.) or lower-case (Ltrs.)

You can see how these are coded by looking at them in your own stunt box when you have an occasion to take it out again. The "blank" in slot 22 has only five tynes left on it, the five "information" tynes on the right side for "spacing" only. Yet the "blank" in slot 28 has been coded for "upper-case" and has an additional tyne on the bottom left side for this purpose. The "upper-case S, print only" for the bell in slot 30 is quite interesting--it will have the top right tyne, then the five information tynes arranged to respond to "S", and finally the bottom left tyne for upper-case. These are various examples of how function bars are coded. Additional information is shown in the chart on page 65 of section 573-115-800TC of the 1148B parts manual. If buying function bars, it is cheaper to buy a "pre-coded" one rather than the "un-coded" one which you then modify to suit yourself by snapping off the appropriate tynes.

FUNCTION PAWLS

For all practical purposes there is only one function pawl. However, for an occasional special purpose, there is a special pawl available that has an extra long projection on the side. This allows one pawl to operate two function levers simultaneously. It must be used in conjunction with a matching pawl. Thus you can see that only in the most unusual circumstances would you (as an amateur buying his own parts!) want to go this route. It is normally possible to substitute other methods whose end results are similar, and much cheaper.

SWITCHES

Various switch block assemblies are available, but most look quite similar to the one already in your mouse machine. That is a 4-switch block, but only two switches are being used. You can buy the small spring contacts needed to fill out the block if needed. The switch contacts are available for normally open or normally closed operation. In the one case (normally open) they look like those presently in your machine. In the other case the top of function lever pushes the switch contact up instead of letting it down as the lever is moved.

SWITCH CURRENT

This little bit of information is very important to keep in the back of your mind, tucked away for further reference at some time:

THE SWITCH CONTACTS ARE RATED AT 100 MILLIAMPERES MAXIMUM CURRENT.THEY REMAIN CLOSED FOR NO MORE THAN 54 MILLISECONDS AT 60 SPEED UNLESS LATCHED DOWN BY THEIR ASSOCIATED FUNCTION LEVER.

SPACING SUPPRESSION

A bar runs the length of the stunt box, but is slightly below it, and not a part of it. This bar, when pulled toward the front of the typing unit prevents the spacing clutch from moving the type box along the page. Any of the 42 slots can be programmed to prevent spacing. Certain slots like those used for non-typing functions such as "LTRS", "FIGS", "BELL", "CARRIAGE RETURN", "LINE FEED", etc. are fixed in this manner.

SHIFT FORKS

Various types of shift forks and shift fork slides are available. One excellent example is already in each mouse machine above the first three slots. This particular shift fork operates the bottom "FIGS-LTRS" code bar via a vertical post which goes up to meet that shift fork.

We have given you an inkling of how the components in the stunt box work in an individual slot. We have given you at least a vague idea of how various components are already in your present stunt box.

You are probably ready now (at least as much as you ever will be) to take the plunge for dismantling the stunt box so you may install the auto CR-LF system. This is not particularly difficult, just somewhat time-consuming, but tremendously interesting if you have any mechanical talent at all, and quite personally satisfying to realize you have accomplished it yourself.

The major thing remaining to do to the 28KSR "Mouse" machine is the installation of auto CR-LF. We have been delaying this until now so that we could give you the proper background to understand what would be needed. If you have read the previous five articles, you should now be ready.

AUTO CR-LF

Perhaps before we explain how to install it, we should attempt to tell you just what happens in the typing unit after we do have all the parts installed. This should make their installation somewhat more simple.

Therefore the following explanation jumps the gun insofar as we assume all the parts are already installed:

Looking at the front of the typing unit, a rather large round wheel is seen on the front, toward the right. It is called the "spacing drum" and has notches along the outer circumference. If you look at Fig.3, the arrow points to the bellcrank. This has a projection on it. As the spacing drum rotates toward the right margin, this projection collides with the right margin stop on the rear of the spacing drum. This causes the bellcrank to tilt. The top of the bellcrank then causes the "Zero" code bar to be pulled to the right.

Up in the stunt box, in slots 4 and 39, we have some function bars coded so that at anytime this "Zero" code bar is pulled to the right, they can operate on the very next character of function that occurs. As we mentioned, anything in slot 4 can operate the line feed mechanism. As a result, whenever the "Zero" code bar is pulled to the right, then on the next character typed or received, the auto CR-LF takes over, and since you have now moved away from the right margin stop, of course the bellcrank returns to normal position, allowing the "Zero" code bar to go back to the left (out).

So there are several things that

have to be in the machine to allow all this to happen.

1. A bellcrank is needed with bracket, as shown in Fig.3.
2. A rear ring is needed on the spacing drum that has the proper projection to collide with the bellcrank bracket.
3. We must have the "Zero" code bar.
4. We need parts in slots 4 and 39.

WHAT DO WE HAVE NOW?

This you shall have to determine. We had you determine part of this already, in order to send for the parts needed. About 75-80% of the machines apparently have "most" of the parts needed already. The other 20-25% need "the works" added.

If when looking at Fig.1 and then checking your machine, you find you have a code bar for the "0" slot, and then after looking at Fig.2, you determine on your machine that you do have that particular bellcrank, your problem is pretty simple to complete. All you have to do is take the 157514 mod. kit we had you order, and install the little bracket in the "horse's mouth" (shown in Fig.2) so that you wind up with Fig.3. THEN YOU ARE DONE WITH EVERYTHING EXCEPT ADDING THE PARTS TO SLOTS 4 AND 39!

If you are one of the 20-25% of fellows who did not find the "0" code bar to be in your machine, and consequently did not find the bellcrank shown in Fig.2, you will have to wait for some more articles that shall follow this one, in order to add the parts we had you get. In any event, EVERYBODY will need to add the parts to the stunt box, so this article will concentrate on that.

ADDING AUTO CR-LF TO THE STUNT BOX

We had you remove the typing unit, take out the stunt box and exchange function bars 5 and 38 to give automatic non-overline. That was also a "warm-up" to installing the parts needed for auto CR-LF which is a bit more complex.

So, review removing the stunt box, if necessary.

Remove the typing unit, remove the stunt box. To make it easier to handle the stunt box, you might as well remove the electrical switch block on the stunt box. It is held in place with two bolts that go through its top. It won't hurt if the switch falls apart, but it is a little more convenient if it doesn't. You can put some nuts on the bottom of the bolts, or use some Scotch tape to keep it together.

The wires are tied in a channel bracket that runs the length of the stunt box. At either end, this channel bracket will have a small bolt holding it to the stunt box end piece. Take those little bolts out and then you can pick up the stunt box and it will be free of the electrical wires and from the typing unit. You may now set the typing unit in another part of the room where it will be out of the way.

Fig.15 shows one end of the stunt box. The arrow points to a thin retaining plate (part 152889) which has to be removed before you can dismantle the stunt box sufficiently to install new parts.

So, take out the bolt just to the right of the arrow in Fig.15, the retaining plate will slide down and off. You can temporarily replace the bolt to keep the end bracket in position (part 153299). Now go to the rear of the stunt box, and you will see another angle bracket running the length of the stunt box, near the bottom, between the end brackets. (Part 153581). Remove the bolts at either end holding this in place.

Now you can go back to the end bracket and again take the bolt out. Just tug the end bracket clear off, and this will allow the removal of the stripper blade (part 155061) (probably on your unit) and the round shaft (153295). In Fig.16, these have all been laid out. Two of the three bolts came from the angle bracket at the extreme left, the third from the end bracket at the bottom right.

When you removed the 152889 retaining plate, there was a small rod that probably fell out of the stunt box, or wanted to. This rod had been held in place by the retaining plate, and is shown in Fig.15 as being in the 10:00 position from the bolts you removed and perhaps a quarter-inch from it. This is the rod that holds the function levers from slipping out of position, but has to be removed in order to install any additional function levers anyway. Don't worry about that rod just now, as you cannot keep it exactly in place anyway without the retaining plate in position.

INSTALLING THE PARTS

You are now ready to start installing the parts in slots 4 and 39. It is not at all hard, and in fact you will find it most interesting.

In this case, a small embroidery hook is all but indispensible. I have several sizes, but find the size "13" to be ideal. Teletype Corp. also has special tools just for this purpose: 142554 which is a small hook and the 142555 which is a "double hook"--that is, you can push or pull either one. They also sell what appears to be a no.12 embroidery hook--151959.

At any rate, the function pawl goes in first. Refer to Fig. 10 - the "pawl" is at the top of the picture. Since you already have several examples in front of you while looking at the stunt box, just slide the pawl in slot 4, similar to the appearance of the pawl in an adjacent slot such as 5. We origianlly had you order two sets of slot parts (153916) and the pawl, springs, etc. will be in that package.

There will be three springs and one cotton wick. Take the spring with the "bent-end", stick the wick inside, and hook between the end of the function pawl ("bent-end") and the front plate. You can refer to the other function pawls in the stunt box for this.

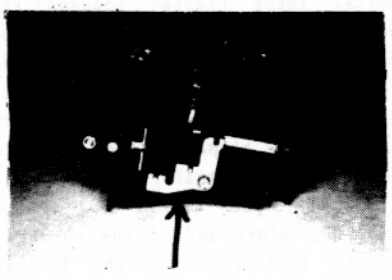


Fig. 15 -- left end of stunt box, showing the retaining plate that holds the small rods in place.

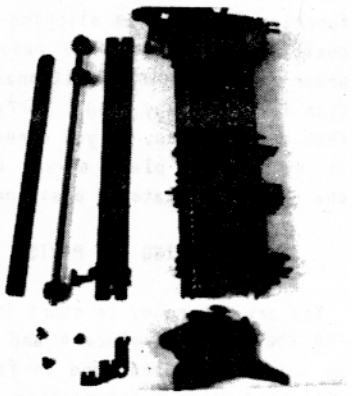


Fig. 16 -- Stunt box disassembled and ready for parts to be installed.

Next comes the function lever. As it is all but impossible to install the spring AFTER the function lever is in place, put the one end of the spring on the function lever prior to inserting it in the stunt box. This is the shortest spring of the three.

If you can't figure out which side the spring should stick out, look at Fig.11, and it might give you a better idea. You install the function lever so the open part of the "C" faces the front of the stunt box, so the spring should stick out the "other way".

After the function lever has been wiggled around into place, install the 152660 spring plate similar to those in other nearby slots. After hooking the "tail end" you can then pivot it around until it snaps into place. If you have to push more than moderately hard, you may wish to loosen that bottom rod a little. If you look on the bottom side of the stunt box, you will see several small bolts. These tighten spacers that hold that bottom rod in position. Just loosen the one that is closest to slot 4 temporarily, and this will enable you to easily insert the spring plate properly, then retighten the bottom bolt again.

Now take your hooked tool and engage the other end of the spring on it so that it holds the function lever into place.

Do the same for slot 39.

Now you are nearly finished. You can at this time either reassemble the stunt box or install the function bars in slots 4 and 39. No matter. Let's install the function bars so we can say we are finished with all the parts themselves.

We had you order two 152671 function bars. These look quite unusual with respect to the "business end" as only one tyne remains, and that is in an unusual position. This one tyne is called the "Zero" level,"non-select". Since the "Zero" code bar is normally "out" or to the left (marking position) these function bars can never do anything unless, until and if that "Zero" code bar has first been pulled "in" to the spacing positon, which is called "non-select". Then, the 152671 function bars can operate at any time and on any character, since they have no other tynes and thus respond to "anything".

The remaining spring is the longest of the three and retains the function bar. Just shove the function bar in the slot on the front of the stunt box. You may have to push and pull slightly, and you may find it easier if you hold the function pawl up at its rear end to allow the function bar to slip in under it more easily. Hook up the springs and you have finished all the work in the stunt box that we had in mind for this time (installation of auto CR-LF).

This may seem a bit "after the fact" but we hope you read the entire article before you start any actual work in the stunt box anyway.

GET SOME GREASE OR HEAVY OIL (EVEN VASELINE) AND WITH YOUR FINGER, PUT A LIGHT COATING OF GREASE ON THE FUNCTION PAWL, FUNCTION LEVER AND PARTICULARLY ON BOTH SIDES OF THE FUNCTION BAR PRIOR TO INSTALLATION.

REASSEMBLING THE STUNT BOX

Continue to leave out the rod that fell out when you origianlly removed the retaining plate (152889) from the end bracket (153299) as it will only get in the way at this time. Set the stunt box on end, so that the end from which you remove the retaining plate is in the air. Now place end of the stripper blade in the bottom bracket, making sure the end with the added piece is "up". The stripper blade goes in the slot in the end bracket that is closest to the function levers. Notice at each end of the stripper blade is a small notch. This engages the arm (153301) that is attached to the end of the bracket.

Now install the shaft in the hole in the bottom bracket. You will note that the end of the shaft has an eccentric that engages that hole in a certain way, so that when the shaft is turned, it moves the arm, causing the stripper blade to move.

OK, now take the remaining end bracket and install on the top end. This is not a difficult job if you do it as we suggested, with the stunt box standing on end. You will have to go back and forth between the stripper blade and the shaft until both fall into place, and then you will need to wiggle the end bracket around a bit to get it to position correctly over the rods that stick out the end of the stunt box frame.

Put the bolt in that holds the end bracket on. Now for the time being, we will forget all about that other rod that has not been put into place, and we will for the moment forget about the retaining plate on the end.

Now install the "angle bracket" between the rear ends of the end brackets.

OK, we are ready for the "fun" now. We are ready to put in that remaining rod through the center of the stunt box. First, look at all the tops of the function levers to see they are in proper position. Then insert the rod from the "bottom end" of the stunt box so that the end of the rod with the little groove that the retaining plate holds will come out the top end. It might have such a groove on each end, so no bother in that case.

Try to wiggle the rod so that it comes out the top bracket far enough that the retaining ring grip that groove we mentioned. When successful, lay the stunt box on the bottom side, remove the bolt holding the end bracket to the stunt box (it won't fall off), slip the retaining plate into place, reinsert the bolt into the end bracket, and you are all finished with the installation of parts into the stunt box.

REPLACING THE STUNT BOX

You are now ready to replace the top bracket and electrical switch. As soon as this has been accomplished, you can put the stunt box back into the typing unit. As this was discussed in great detail, we shall not go into it further at this time.

TRYING IT OUT

You can easily see if things are going to work. Just type well over to the right margin and keep typing. As soon as the bellcrank collides with the projection on the rear of the spacing drum, it should pull in the "Zero" code bar, and then whatever you type next, it should return the carriage and turn up a new line.

Again, if you are one of those without the code bar or bellcrank, of course nothing will as yet happen, as you have some additional work to do. Also, this assumes those having these parts have already installed that small bracket into the bellcrank, as shown in Fig.3.

SETTING THE RIGHT MARGIN

You "75-80%" who are all done now, will want to check the total length of line you can now get prior to an automatic CR-LF action. You should get 73 total spaces, and on the 74th have it automatically return.Normally this would be only 72 spaces and return on the 73rd, but since we had you install the simple non-overline, this system works properly when set for one additional character, due to the nature of its operation.

On the spacing drum there are five bolts holding the front and rear rings to the spacing drum.These bolts are visible in Fig.2, to some extent. One of them is about halfway between the arrow and the center nut of the spacing drum itself. You can see another bolt to either side of that one, and one more to the bottom of that ring. One of the five is hidden from view by the frame that holds the spacing drum in position.

Going clockwise, you will see that the 1st, 3rd, and 5th are all "round-head" bolts and the 2nd and 4th are "hex-head" bolts. The 2nd holds only the rear ring (right margin)in place, and the 4th holds the front ring only (left margin). The three round-headed bolts hold both rings.

This may be a bit confusing, but it will soon straighten out. You must loosen all three round-head bolts to move either the front or the rear ring. Then you loosen either the 2nd (for moving the rear ring for right margin adjustment) in addition, or the 4th (for moving the front ring for the left margin adjustment).

To summarize, you have to move four of the five for either the front or the rear adjustment.

If you are satisfied with the present left-margin, just make sure you do not loosen that 4th hex-head bolt at all, and you'll be in business.

At any rate, to adjust the right margin, loosen 1, 2, 3 and 5--then you can easily push the rear ring around with a screwdriver about the equivalent of one notch, and temporarily tighten several of the bolts again while trying the line length once more. Moving the rear ring counter-clockwise will lengthen the line, moving it clockwise will shorten the line.

If you decide to adjust the left margin, several hints are in order.

First, note how the ratchet fingers grip the notches on the circumference of the spacing drum, so you can duplicate this position after you have moved the ring sufficiently for your purpose. Second, make sure before you loosen the 1, 3, 4 and 5 bolts (no.2 is for the rear ring, remember) that those fingers are engaging the spring drum and that you are not resting on the left margin stop itself--that is, you are "away from" the left margin and stopped say in the middle of the page. This takes the pressure off the left margin stop so it will not change until you push it around yourself. Otherwise it could "get away from you". We recommend on general principles that you do not move the left margin at all unless for some reason you feel you would really like to. It's not a difficult job, but it does add some unnecessary work in getting the fingers to engage the notches properly once more.

RESULTS SO FAR

This has taken us through a lot of changes. Feel good for as of now, we have completed all the changes needed to put the mouse machine into normal amateur standard. We now have communications type, communications keyboard, non-overline, auto CR-LF (except for that 20-25% who will have to read a few more articles yet), and we have learned how the stunt box works, how to take it out and how to install parts. Indeed, you have most likely learned a lot more about this 28KSR already than you ever knew about the model 15 or 19 or 26 that you had been using previously. You are ready for the "icing on the cake" which are the optional things you can put into the stunt box. However, we shall have to ask your indulgence while we explain to the 20-25% of the fellows how they can install their "Zero" code bar, bellcrank and rear ring on the spacing drum before we can continue with some of the special things you might want to do with your stunt box. So those of you who now have auto CR-LF operational, can skip the next two articles as they will hold little interest for you, other than general information now that you are somewhat familiar with the mouse machine. Most of you owning 28KSR's should now have auto CR-LF and other standard amateur communications features. However, there is a small group who did not have the 'Zero' code bar or bellcrank installed in their machine.

WHAT HAS TO BE DONE?

"Zero" code bar

It will necessary to do the following things:

1. Remove the front plate
2. Remove and dismantle the code bar assembly
3. Install the new "Zero" code bar
4. Reassemble the code bar assembly
5. Remove the spacing drum from the front plate
6. Install the bellcrank
7. Replace the "rear ring" on the spacing drum with a new one
8. Replace the spacing drum in the

front plate
9. Replace the front plate

This assumes of course you have already installed the parts in the stunt box.

This will probably sound like a lot of work, and indeed it is a bit of bother, but not 'too hard' at all, particularly, if you have some adequate instructions. Everything mentioned can easily be done in one evening.

REMOVING THE FRONT PLATE

This is actually a much easier job than taking off the stunt box. There are three basic things to do:

1. Unhook the bail arm from the type-box
2. Take out four large corner bolts
3. Take out two smaller bolts underneath.

First, we want to disconnect the type box. This is pulled along by the wire that runs directly in front of the type box. Attached to this wire directly in front of the middle of the type box is a bail arm (154356) which goes through a hole in the bottom right side of the type box carrier plate (153530) and is held there by a "C" type retaining ring on the backside. Now to disconnect that bail arm.

Type a "LTRS" character and then turn the motor off. If using the line shunt relay, you will automatically revert to "blank" as the motor runs down, no matter. Now reach up to the left side of the "printing carriage frame" (153820)--another descriptive term would be the type-hammer carriage directly in front of the type box--and just push it to the right as fas as it conveniently wants to go. You can return it to the left via the red button on the top row called "LOC CR" if you want to try it several times.

At any rate, this should move the type box assembly to the right far enough that the bottom right side, where the end of the bail arm is connected, can be seen, and the "C" retaining ring can be removed from the rear. Then pry the arm out of the hole and now the type box is free to slide around. While holding this bail arm so it won't catch on anything, and holding tension on the left side of the print-hammer carriage, depress the red button "LOC CR" and slowly allow the carriage to return to the left margin stop.

Next we want to remove the two "underneath bolts". These are attached to the main rocker shaft (150365). This is a square "rod" about 3/8" square. It is located directly behind (2") the "take-up" wheel (pulley) (150758) for the front wire going between the two large circular drums. This pulley is 1" in diameter and is located 3 5/8" from the center of the left spring drum, in a 4:00 position. When you locate the square shaft 2" behind that pulley, you will find a bolt on the bottom side of the rod about 1 1/4" left of the take-up pulley and another about 1 1/4" right of the pulley. Remove both of those, releasing the bracket (150245) which is part of the front plate assembly.

Now finish removing the front plate. This involves four large bolts, one of which is about 2" from the center of the left-hand spring drum in a 10:30 position, another is about 2 1/4" in a 7:30 position, a third is about 2" from the center of the right-hand spacing drum in a 1:30 position, the fourth is about 2 1/4" in a 4:30 position.

Now you can lift off the entire front plate assembly. Before you do, however, note the right-hand spacing drum. On it's left side there are two feed pawls ("fingers") (150678) which advance the spring drum. At the bottom of these feed pawls you will see a circular piece of metal called a "retainer" (150203). This has two parallel lines drawn on it which should line up with a small line on the end of the front feed pawl. Keep this in mind for when you replace the front plate, you will want this situation to again exist.

NOW THE FRONT PLATE IS OFF

1. Remove the dash-pot cylinder (150538) from the front bottom right-hand corner of the front plate. This involves removing two very lage "C" retaining rings and two springs from

Figure 17...Showing the rear ring needed on the spacing drum for auto CR-LF. The new 154626 is on the left, the old 154625 on the right. Note the new one has an extra tab,which engages the bellcrank to move the "Zero" code bar.

the post at the left end of the slide that goes into the dash-pot cylinder. This post is 7:00 position from the center of the right-hand spacing drum about 2 1/8".

2. Remove the three bolts on the rear of the dash-pot cylinder. Now the cylinder can be removed from the post (stud) by wiggling if off, at an angle. Nothing else need be removed to allow this.

3. Note, there is a wire going between the spacing drum and the left-hand spring drum. It goes over the take-up pulley wheel we mentioned earlier when removing the front plate. Push down on this take-up pulley and slip the wire off its top. This removes the tension on the wire.

4. Assuming that the print-hammer carriage is at the left margin stop (to make certain, hold the right-hand spacing drum tightly with one hand while lifting the ratchet fingers (feed pawls) from contact with the spacing drum and then see if that right-hand drum wishes to rotate counter-clockwise at all, if so, you were not on the left-margin stop, and let it slowly rotate until you are.) When at the left margin, you will see that lower wire we just mentioned (3 above) is attached to the left-hand spring drum by a bolt. Remove this bolt and now the wire is loose. Pull the wire free from the spring drum and note how the wire is "threaded" in the vicinity of the spacing drum, so you can eventually pull it back in a similar manner. DO NOT REMOVE THE RIGHT END OF THE WIRE FROM THE SPRING DRUM, IT IS NOT NECESSARY.

5. Now rotate the spring drum clock-wise with your fingers until

the bolt hole where the lower wire had been attached is now about the 10:30 position.

6. Take a screwdriver and drop through the 6:00 position of the spring drum, down through the front plate frame. This will hold the spring drum from unwinding and loosing its tension, when we soon lift the feed pawls from the spacing drum.

7. Now do just that--while holding the right-hand spacing drum, "pick-off" the feed pawls (ratchet arms) with a screwdriver or your fingers. Then allow the spacing drum to rotate counter-clockwise slowly to where the left-hand spring drum is now resting entirely on the screwdriver you have stuck in it.

8. Remove the pulley wheel (150224) from the rear side of the top front track (152579). There are two pulley wheels in that vicinity, it is the front one of the two. Before removing it, take a pencil and mark the position of the washer, and that wheel can be positioned in a slot to vary the spring tension, and you will want to replace it in its present position.

9. Directly below this top right-hand corner of the track, about 1 - 1/2", are two other nuts in the lower plate (150554). Remove both nuts, which hold two guide plates in position--one in front and one in the rear. Note carefully that on the front side is another small spacer shim (150805) between the front guide plate and the main frame plate. You may want to draw yourself a picture of how these parts were removed before you continue.

10. Now remove the nut and washer from the center of the right-hand spacing drum, both on the front and rear sides of the drum.

11. The spacing drum may now be removed by pulling up on the front frame plate (150554) at the bottom right-hand corner (near where the serial number of the typing unit is located) enough to allow the spring drum to be removed.

12. Now remove the spacing drum, and you will still have several wires dangling from it, but this will not prohibit your doing everything that is necessary to it.

13. Note that there are five bolts on the front about 5/8" from the center and in a cirular arrangement. Remove the 1st, 2nd, 3rd and 5th(clockwise from left to right) being certain to leave the 4th (hex-headed bolt) tightly fastened. This keeps the left-margin stop (front ring) in its original position, which is fairly important.

NOTE: PRIOR TO REMOVING THESE BOLTS, TURN THE SPACING DRUM OVER AND WITH A PENCIL OUTLINE THE POSITION OF THE LARGE RIGHT-HAND MARGIN PROJECTION--THEN OUTLINE THE EXACT POSITION ON THE FRAME, SO THE NEW RING CAN EASILY BE POSITIONED LIKEWISE.

14. Now the rear retaining ring (154623) may be removed and the rear margin ring (154625) may be removed. You will now put the new margin ring (154626) where you just removed the old ring. Replace the retaining ring and replace the bolts, remembering that the hex-headed bolt was no.2, and the three round-headed ones were 1, 3 and 5.

NOTE: Fig.17, although a poor photograph, adequately shows the difference between the new (154626) ring on the left and the old (154625) ring on the right. The extra tab on the new ring operates the bellcrank for auto CR-LF when it approaches the right margin.

15. We are done with the spacing drum, but do not replace it as yet. Now install the bellcrank. This is part no. (150438) in the 152348 mod. kit you ordered originally which included the "Zero" code bar (153319) and the new rear margin ring (154626) you just installed.

16. You will find a bolt on the very rear of the back frame piece of the front plate. This bolt has a nut on the inside of that rear plate. You will find this nut in about the 12:30 position and 2 1/2" from the post (stud) that holds the dash-pot springs you removed earlier when you took the dash-pot cylinder off. The bellcrank fastens to that bolt, so remove the nut, put on the washer, then the bottom of the bellcrank so it will point up from there when finished, then the nut and tighten. The bellcrank should be free to rotate a little on that bolt when done. The spring now attaches from the left hand center side of the bellcrank downwards about 7:00 position and hooks to the small area of the rear plate about 3/4" down.

17. Now you have essentially finished everything and are ready to put it all back together. You still have the "Zero" code bar to install, but that is done on the typing unit itself and not on the front plate. It will be discussed later.

18. Turn the spacing drum right-side up, making sure that two overhead wires are not twisted, Slip the spacing drum back in place, raising the bottom corner of the front plate high enough to allow this.

19. Make certain, the rear end of the spacing drum's "axle" is seated correctly as it has a flange on the rear that has to find a proper position in the rear hole before it will go fully into the hole. Then replace the rear washer and nut, and do likewise on the front end as well.

20. Replace the front guide plates with the shim plate also. Then replace the pulley wheel, making sure it is in the same postion as it was originally by checking your pencil mark to center the wheel properly.

21. While holding tension by hand on the spacing drum, position the various wires properly over the pulley wheels. Do the two first.

22. Now, since you probably have tension on the feed pawls (ratchet fingers), hold the spacing drum while again "picking off" those feed pawls, and let the spacing drum rotate slowly counter-clockwise until the spring drum tension takes up the slack. Now, while holding the spacing drum carefully, remove the screwdriver in the spring drum and let both of them slowly rotate back to the left margin stop while holding the feed pawls free to allow this to happen. When on the left margin stop, you can let go of the spacing drum, and the left margin itself will hold things in a normal manner to keep the spring drum from unwinding any further.

23. Now rethread the bottom wire but do not as yet put it over the

take-up pulley wheel. Instead, reconnect to the spring drum by putting the bolt back in place--this should be in about the 8:00 position.

24. Depress the "take-up" wheel and put the wire over it, and release.

25. Replace the dash-pot cylinder, replace the springs on the post, replace the two large "C" retaining rings on the post.

26. You are finished with the front plate. We'll now put it back in position on the typing unit.

REPLACING THE FRONT PLATE

There are several things to watch for to make sure they engage properly.

1. The bellcrank to engage with the "Zero" code bar slot.
2. The Figs-Ltrs shift code bar engaged with the lever on the front plate.
3. The small horizontal "bellcranks" (150771) which might be called "transfer fingers" that are at the rear of the front plate and near the top, in the middle. These engage several of the code bars in the typing unit.
4. Finally, be certain that the circular plate on the end of the feed pawl fingers that advance the spacing drum, are lined up with the mark on the top pawl. If not, pull the front plate free far enough to rotate the gear (150202) on the other end of that shaft until it does line up properly.

If all these conditions are met, then reconnect the front plate, probably starting backwards, with the four large bolts, one in each corner, then reconnect the bracket to the main rocker shaft underneath via the two small bolts, and finally push the typing box and typing-hammer carriage to the right end again and reconnect the bail arm, replacing the "C" retaining ring.

Do not worry as yet about adjusting the right-hand margin until after you get the "Zero" code bar installed.

SUMMARY

You have now learned how to easily remove and replace the front plate. You now have a bellcrank installed which will allow auto CR-LF action if you have the "Zero" code bar and the stunt box components installed. This particular bellcrank is not the same one that the "75-80%" will have, but that is not matter. Yours is the 150438, theirs is an "universal" 157-972 to which you can (must for auto CR-LF) add the 157514 mod. kit, which then gives a bellcrank that does the same thing that your 150438 will do. Since you will most likely "always" want the advantages of auto CR-LF (and so will they), this is no further important.

If you attempt to follow the instructions included in the 152348 mod kit, you will see they have you remove the spring tension from the left spring drum, etc. This is "one way", but it assumes, you have a spring tension gauge in order to replace the proper spring tension once more.While 1-2 of you might have access to such a gauge, the rest won't, and I think this system is actually more simple even if you did have the spring gauge to start with.

I suggest you make no attempt to follow the instructions included in the 152348 mod. kit, as our experience with other people has indicated, those instructions will be most confusing to the typical amateur doing this for the first (and probably only) time.

HOW IT WILL BE DONE

In general, we shall have to (1) remove the front panel, (2) remove the code bar assembly, (3) dismantle it, (4) add the "Zero" code bar, (5) reassemble the code bars, (6) replace the code bar assembly, and (7) replace the front plate.

REMOVING THE FRONT PLATE

Although we already covered this for normal circumstances, it will be necessary to use a different technique in this case. Otherwise the track upon which the type-box rolls (150824) will not be lifted high enough to allow the code bar assembly to be pulled out of the typing unit properly.

Since when the machine is shut off, the internal loop voltage stops, and the line shunt relay isolates from the external loop of the "TU" or "demodulator". Thus we shall have to pull a few minor "tricks" to fool the machine into thinking it is still "on". We shall do this by disconnecting the motor. Now to proceed.

1. Remove the typing unit from the keyboard base. This has been discussed before. It involves four large bolts, one at each corner of the typing unit, and disconnecting the cable about 5" to the rear of the right ribbon spool.

2. Find the motor on the keyboard base. About 4" to the left of the left edge of the motor is another cable connector. Directly in front of that about an inch is a terminal block with fiber cover.

3. Remove that fiver cover, and disconnect one or both of the heavy motor lines. Either place where they will not touch anything, or just tape, temporarily.

4. Now replace the typing unit on the base temporarily (no bolts needed) and connect the cable once more to the rear of the right ribbon spool.

5. Turn the power switch back on. The motor will not run as it has been disconnected, but everything else will be normal.

6. Type a "K" on the keyboard, and with your finger, turn the motor counter-clockwise (as viewed from the right side of the cabinet) until the hammer is about to strike the type box.

7. Now remove the typing unit once more, of course disconnect the cable first.

8. With your fingers push the type box as far right as it will conveniently go.

9. You should now review "REMOVING THE FRONT PLATE", as from here,everything is the same as in that article.

10. Remove the "C" retaining ring from the bail arm that holds the type box to the print hammer carriage wire, you will remove the two "underneath bolts" from the rocker shaft, and the four large bolts that hold the front plate to

the typing unit.

11. The front plate may now be set aside as it will not be used for any further purpose at this time. You first might wish to return the print hammer carriage to the left margin stop. You can do this by holding the right spacing drum with your fingers, while "picking off" the feed pawl fingers that advance the spacing drum and holding them out of the way while you slowly allow the spacing drum to rotate counterclockwise to the left margin stop. Watch the bail arm that you disconnected from the type box to make sure it doesn't get caught on anything in the process.

12. You will notice the code bar assembly running the width of the typing unit, and in about the middle, vertically.

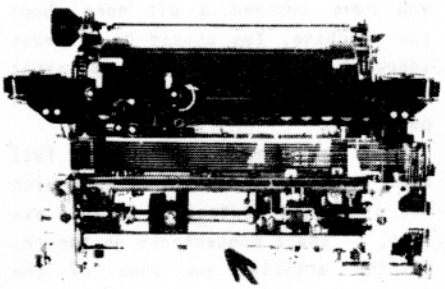
13. This code bar assembly is held between the two main frame plates of the typing unit that also hold the paper spool at each end. Look at the right end of the code bar assembly and you will see the transfer system that operates the code bars. You will see the arms that connect to the code bars to move them. From directly in front of the selector magnets, go left 2" and notice on the code bar assembly a triangular shaped plate (150301) that is held to the base of the code bar assembly with two bolts. Remove this triangular plate. Now note that there are two types of bars that connect the code bars themselves to the transfer mechanism in front of the selector magnets. Note that three of them are fairly short and hook directly in front of the piece you just removed, while three others are longer and hook (with springs) about 1 3/4" further to the left. Remove all six of these bars, the ones with the springs just push on and you can pry them off, you can remove the springs after the bars are off, or nearly so.

14. Now you are about ready to remove the code bar housing itself.Look at the left side of the code bars, then look about one inch to the left of the center of the code bars and you will find two bolts, one above the other on the left frame of the typing unit. Remove both of them.

15. Now look in a similar position on the right side of the typing unit, and you will find two more that hold the right end of the code bar housing to the typing unit frame.Remove those two.

16. Now the entire code bar housing should pull right out of the typing unit.

17. From here on in, there isn't too much we can help you with via the printed word. First, remove the 6" piece (bracket) (154380) from the top of the housing. Use a large enough table; you can put these items in their relative position on the table as you take them off.



Typing unit after front plate has been removed. Arrow points to the square rocker shaft. Two bolts are removed from the middle of this shaft as part of the front plate removal procedure. The code bar housing can be clearly seen a few inches above this rocker shaft.

18. Next, remove the top piece that is held on with two quarter-inch bolts 9 5/8" apart. To do this, you first have to remove the two small bolts about in the middle of this "tie bracket" (153321). Those two small bolts hold the center "guide bracket" (150304) which keeps the various code bars spaced, vertically.

19. You will now want to remove the left-hand assembly. First, you will notice on the front left-hand side two plates side-by-side. Each has two bolts holding it in place. Remove the right-hand plate first and pull off. Then remove the left-hand plate,keeping in mind there are a total of 7 springs and ball bearings beneath this plate. They will not pop out if you are even moderately careful.

20. When the plate is removed, take out the springs and all the ball bearings that want to come, by turning the unit upside down, while catching these items. Write down the positions of the springs before you take them out. If you forget, we'll remind you in the reassembly instructions where they go.

21. Do the same for the rear side of the left end, where again you will find 7 springs and 7 ball bearings under the plate.

NOTE: THIS IS A GOOD TIME TO INFORM YOU THAT THERE ARE NO ADDITIONAL SPRINGS OR BALL-BEARINGS FOR THE "ZERO" CODE BAR, SO DO NOT EXPECT TO FIND ANY. THE NEW CODE BAR IS OPERATED BY THE BELLCRANK ON THE FRONT-PLATE WHICH ITSELF IS SPRING-LOADED.

22. From here, the only thing to watch very carefully is the removal of the two long vertical pins (studs () 152089) about a half-inch closer to the center from the bolts you removed to take off the top bracket. These two pins (studs) are about 9" apart. They appear to be screwed down, but do not try to unscrew them! They actually have a hole drilled clear through their side, near the bottom and are "pinned" in place.

23. On the rear, near the bottom of these stud pins, there is a bolt that runs through the bottom of them. Remove each of these small bolts. On the rear of the stud pin on the right hand side, there may be a second bolt near the top--be sure to remove that one also.

24. From here on, it's merely a matter of putting the new "Zero" code bar in place, once all the other items have been removed, such as the vertical post that connects to the bottom FIGS-LTRS code bar. Then reassemble the entire unit like it was. This will be time consuming, but should not be particularly difficult.

25. Put the code bar assembly back in the typing unit, and install with the two bolts at either end.

26. Put the three shorter bars in the right end, then the three longer bars, and hook up the springs.Replace the little triangular plate in front of the code bars once more, and you

should be all finished with this modification.

27. Replace the front plate, again watching for the items mentioned earlier:

1. That the bellcrank engages the slot in the new "Zero" code bar
2. That the FIGS-LTRS code bar is engaged by its lever
3. That the two small bellcranks at the top of the front plate (about the middle horizontally) engage the code bars normally
4. That the circular plate at the bottom of the spacing drum feed pawls lines up with the notch on the front feed pawl.

Then put the bolts back in place on the front plate, including the two on the bottom rocker shaft, connect the bail arm to the type box, and you are all finished.

YOU HAVE AUTO CR-LF

Assuming you already installed the parts in the stunt box, and have installed the bellcrank and rear margin ring on the right spacing drum, you should now be all set for auto CR-LF. As you now approach the right margin, the tab on the rear of the new margin ring should collide with the new bellcrank, causing it to tilt. As the top of the bellcrank is in the slot of the new "Zero" code bar, this should pull the code bar to the "in" position (spacing, or "non-select") which then allows the function bars in slots 4 and 39 to operate on anything next typed or received. This in turn will send the carriage back and turn up a new line, while of course returning the right spacing drum to the left margin, alowing the new "Zero" code bar to return to the "out" or marking position (select).

SETTING THE MARGINS

With auto CR-LF you may wish to reset the right margin stop. This was discussed somewhat, if you wish to review those comments. To summarize, if you DO NOT HAVE SIMPLE NON-OVERLINE, you would want to get a 7-character line, and trip off the auto CR-LF system on the 73rd character typed. WITH THE NON-OVERLINE SYSTEM, ONE EXTRA CHARACTER IS NEEDED FOR NORMAL OPERATIONS. Thus WITH NON-OVERLINE, you would want to respond to the 74th character to automatically return the carriage and turn up a new line.

WHERE ARE WE NOW?

Now everybody should be up to complete amateur RTTY standard, having communications keyboard, communications type, downshift-on-space, non-overline, a "blank key" on the keyboard, and auto CR-LF.

WHERE NEXT

Basically, we have finished with the basic set of articles for putting your Mouse 28KRS into normal configuration for RTTY. At the same time, you have learned a bit more about your machine. You should be at least somewhat familiar now with the stunt box, its operation, and a bit of its potential.

About all that remains will fall into the "I'd like to do that with the stunt box" category. To this extent, we shall concentrate on the remaining articles on some of the things the stunt box can offer and how to do it. It is a bit like setting up a computer since such a vast variety of things "may be programmed". Thus most of the suggestions will be "ideas" which you can incorporate if you wish.

*****

MODIFICATION OF THE KENWOOD TS-820 FOR AFSK RTTY OPERATION WITH 500 HZ CW FILTER

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With the 500 Hz CW filter (Kenwood Part Number YG-88C) installed per paragraph 6.2 (page 34 of the TS-820 Operating Manual) and with the movable connector IF2 installed in Location B per Figure 25 (also on page 34 of the Operating Manual), narrow-shift (170 Hz) stadard tones (Mark 2125 and Space 2295) may be received through the TS-820 with the Mode Switch set to the FSK position.

To operate the TS-820 in an AFSK configuration, it is necessary to transmit with the Mode Switch in LSB, because when in Transmit, the FSK position of the TS-820 generates its own carrier internally, which in turn is meant to be FSKed (not AFSKed).

The following modification permits AFSK operation in both LSB and FSK. The modification itself converts the FSK position of the Mode Switch to a second LSB mode, but with the 500 Hz filter in the bandpass instead of the 2400 Hz SSB filter.

After modification, AFSK RTTY may be transmitted in either the LSB or FSK position of the Mode Switch, and as before, may be received in either position also.

MODIFICATION

With the top and bottom covers removed from the TS-820, locate the front panel Mode Switch, S-6.Although the switch consists of 5 wafers with 10 different switch sections, Kenwood only utilizes 8 of them. Of these 8, only 5 need be modified.

For the sake of this modification, the deck closest to the front panel will be referred to as Deck 1. The last deck on the switch will be Deck 5.

With the TS-820 right-side up, and starting with the front-most deck:

DECK 1 TOP: Locate diode D2 on switch and install jumper across diode.

DECK 2 TOP: No change

DECK 3 TOP: No change

DECK 4 TOP: Terminal 5 has no connection on it. Install a jumper from this terminal to terminals 3 and 4 which have blue wire connected to them.

DECK 5 TOP: No change.

Turn the TS-820 upside-down and modify the bottom side of the Mode Switch in the following manner.Again, Deck 1 is closest to the front panel.

DECK 1 BOTTOM: Clip the two wires (one is black and the other is white with a red tracer) from the switch terminal. Reconnect the two wires together, but not to the terminal.

DECK 2 BOTTOM: Clip the white/purple tracer wire from its terminal and

and tie back so that it cannot short to anything else. Add a jumper from this terminal to the terminal just to the left of it (looking from the front of the TS-820).

DECK 3 BOTTOM: Clip black wire from its terminal and tie back so that it cannot short to anything else. Add a jumper from this terminal to the terminal just to the left of it (looking from the front of the TS-820).

DECK 4 BOTTOM: No change.

DECK 5 BOTTOM: No change.

With the TS-820 still upside-down, locate the X43-1110-00 board. This is the 'voltage-divider' board in the center and towards the rear of the transceiver.

Locate the orange wire that is wire-wrapped on Terminal FSB of this board.

Cut the wire loose from the FSB terminal and tie it back so that it will not short to other terminals or components.

This completes the modification of the TS-820 for narrow-filter AFSK RTTY operation with the Mode Switch in the FSK position.

Replace the TS-820 in its cabinet.

OPERATION

When the front panel Mode Switch is now placed in the FSK position, the TS-820 is actually in LSB (lower side-band) and the CW (500 Hz) filter is switched into the IF section in place of the SSB (2400 Hz) filter.

Connect the TS-820's PHONE PATCH OUTPUT to the audio input of the TU.

Connect the TS-820's PHONE PATCH INPUT to the AFSK output of the TU.

The tones of the AFSK Tone Keyer in the TU should be set for 2125 Hz Mark and 2295 Hz Space, which is 170 Hz narrow-shift.

Tune up the TS-820 in the normal manner, switch to the LSB and set microphone gain for 50 watts output, as read on a good quality in-line watt-meter.

Switch to the FSK postion. If power output drops slightly (because of additional attentuation through the 500 Hz CW filter), increase microphone gain slightly for 50 watts output.

When in Receive, the Passband Tuning (IF Shift) will normally be set at 10:00 (IF Shift will normally be set at 10 o'clock when using the LSB position and ZERO (straight up) when operating the FSK postion.

Generally, AVC should be turned OFF for lowest error-rate copy on marginal signals.

The internal Audio Monitor may be used to 'keep track' of the memory, CW-IDer, etc.

*****

SOME IDEAS ON AUTOMATIC STATION CONTROL

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A number of excellent articles have appeared in various publications describing electronic stunt boxes,SELCAL units, and message generators. In the past year or so, I have built a number of these units, and finally decided to put the whole thing together in one package. I am about to describe the control and interface circuitry used at my station to combine a SELCAL and message generator for unattended operation of the RTTY station. Some portions of the circuit may find useful applications in other projects you may have in mind. It is suggested, if you are not familiar with the "sel-cal", the article written by VE6BV, appearing in the February 1975 issue of "73 Magazine", is required reading.

The SELCAL used at this station has 3 independent "character sequence recognizers", each requiring 4 selected characters be received in order to turn on. Two of them are used to activate the message generator, and one for the T.D. The message generator may be activated alone, however, if the T.D. is activated, the message generator must be activated before the T.D. will operate. The message generator contains station identification in both CW and RTTY (see Dec. 75 issue "RTTY JOURNAL"), thus the station will always be identified at the end of a transmission.

The PTT line turning the transmitter off and on is protected with a timer so that the carrier will remain on the air for no more than 2 minutes under any circumstances. Another timer circuit is also included so that the transmitter is not activated until 5 seconds after the received carrier drops out, assuming the SEL CAL has been activated. While a signal is being received, input F (Fig 1) is held high. When the carrier drops out, input F goes low, and after 5 seconds elapse, the output of U9C goes high, activating gates U11A and U12B.

*****

SIMPLE WIRING FOR THE MODEL 15-19 TELETYPE

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Most nineteens contain excessive wiring and components such as switches, filters, line resistors, relays, brackets, terminals, nuts and bolts, etc. Far more than is required or even desireable for good amateur RTTY. When the average ham takes a first look at his machine and tries to compare it with the diagrams of teletype corporation, which is about all that is shown in the various handbooks, it is no wonder that he is completely lost. But actually, the wiring needed for best amateur operations is extremely simple. So why not get out the cutter, hex wrenches and screw driver and strip the machine down to its basic mechanical parts. This will also give you a chance to clean up all that oil and grime that covers everything on the base, motor, keyboard and TD. It is rarely necessary to strip the printer section so that can be merely cleaned up with rags, swabs, a tooth brush, small wire brush, Q Tips, or anything handy. Just get the excessive oil out of there.

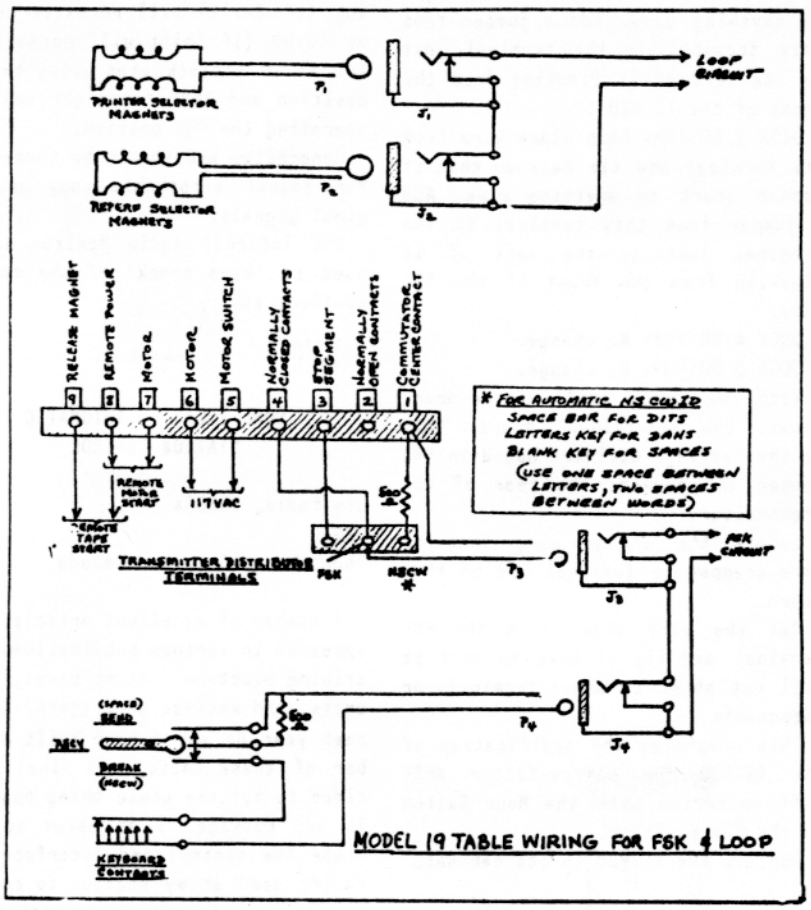
The enclosed charts provide for the simplified rewiring and furnish a basis for later changes and trouble shooting that will be worth far more than the one evening that it should take to get the job done. As far as

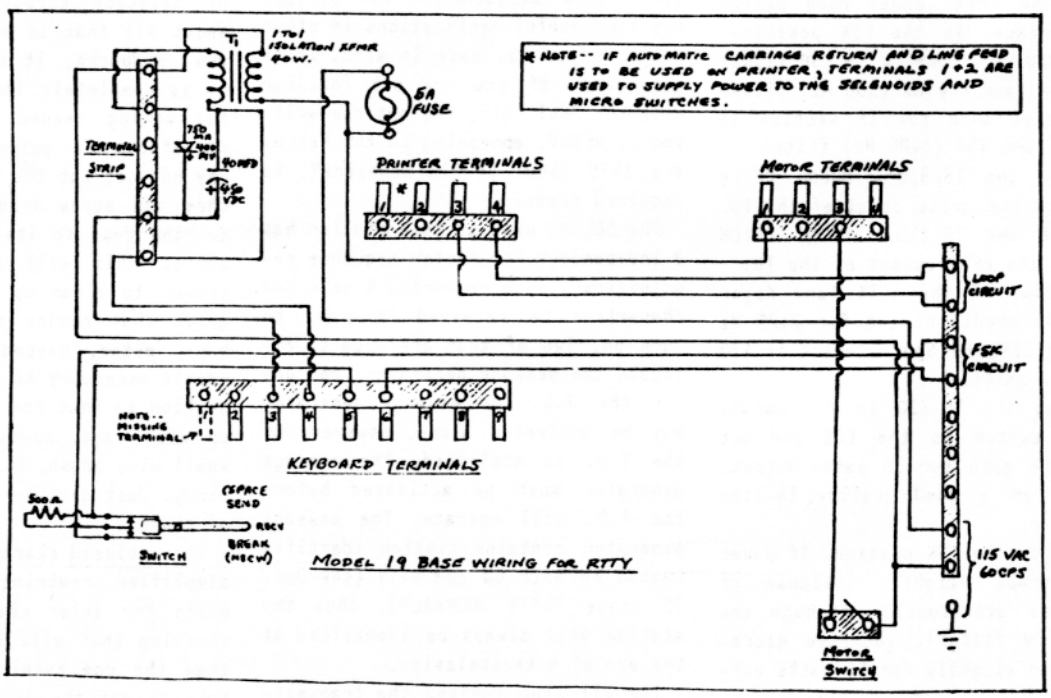
practicable, these charts are oriented to the general location of terminals and other components as viewed from the top and front of the base and keyboard. You will note that provision has been made for certain remote functions that can be added now or later with little difficulty.

The narrow shift CW provision will operate only if the FSK or AFSK line runs directly through the keyboard and TD. But the automatic CW from tape can also be made to operate for wide shift or mark or space make or break. Also note that the send-receive-break tab sticking out of the left front of your machine cover makes a swell little CW ID key if the latching arm is removed. Ours is wired to give narrow shift CW by keying it and to give space when raised up by breaking the FSK line for testing.

If you follow the charts for the power supplies, no outboard supplies will be required, which will leave the back of your table clear for just wiring and terminals. Note punch and TD magnet supplies are merely simple diode circuits from the AC line.

If you have a model 15 instead of the 19, the same diagrams will apply. Just omit any wiring going to the punch or TD.




* NOTE-- IF AUTOMATIC CARRIAGE RETURN AND LINE FEED IS TO BE USED ON PRINTER, TERMINALS 1 & 2 ARE USED TO SUPPLY POWER TO THE SELENOIDS AND MICRO SWITCHES.
1 TO 1 ISOLATION XFMR 40 W.
5A FUSE
TERMINAL STRIP
PRINTER TERMINALS
MOTOR TERMINALS
LOOP CIRCUIT
FSK CIRCUIT
NOTE-- MISSING TERMINAL
KEYBOARD TERMINALS
(SPACE SEND
BREAK (NBCW)
SWITCH
MODEL 19 BASE WIRING FOR RTTY
115 VAC 60 CPS
MOTOR SWITCH

MODEL 15 PRINTER

The model 15 is a page printer, self contained, with keyboard and motor. It has a single magnet selector, which can be operated directly from your Terminal Unit or through use of a polar relay. Two types of selectors are to be found on various models of the 15, first the so called "pull type", magnet which requires the current to be on to pull the selector back after each operation. The second type is called a "Holding Type" selector, which mechanically returns the selector to operating condition after each operation. The later machines have the second type of selector, but does in no manner make the earlier version unsatisfactory. Both types can be operated with the two coils either in series or parallel, to provide 30 to 60 mil operation.

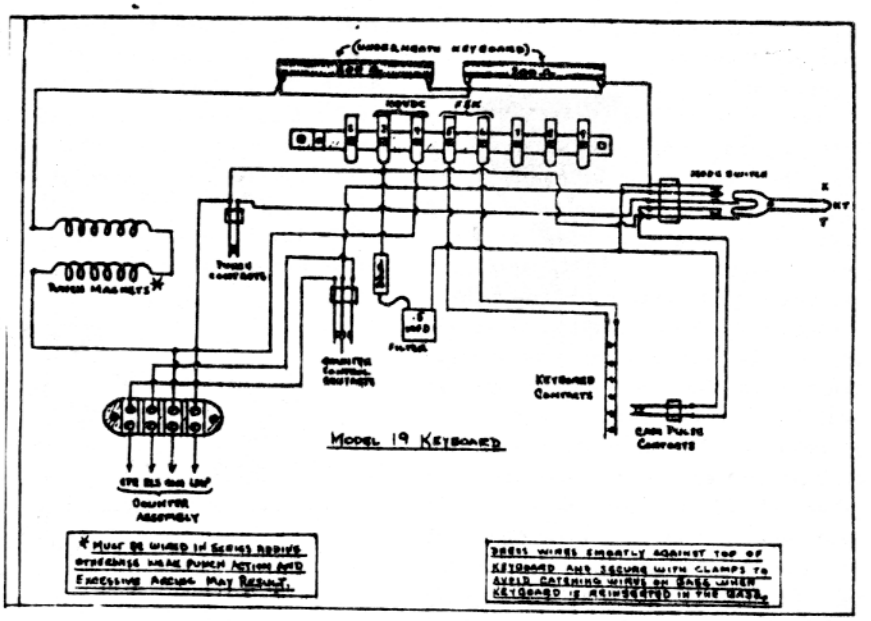
The keyboard has the standard type of distribution assembly, which is similar to that in the model 12, 14, 19, 24, 26 machines. As received, they have the coil and condenser across the contacts which has to be removed for operations of your FSK direct. However, if a polar relay is used, it can be left in place to reduce RF noise generated by the contacts breaking the keying current.

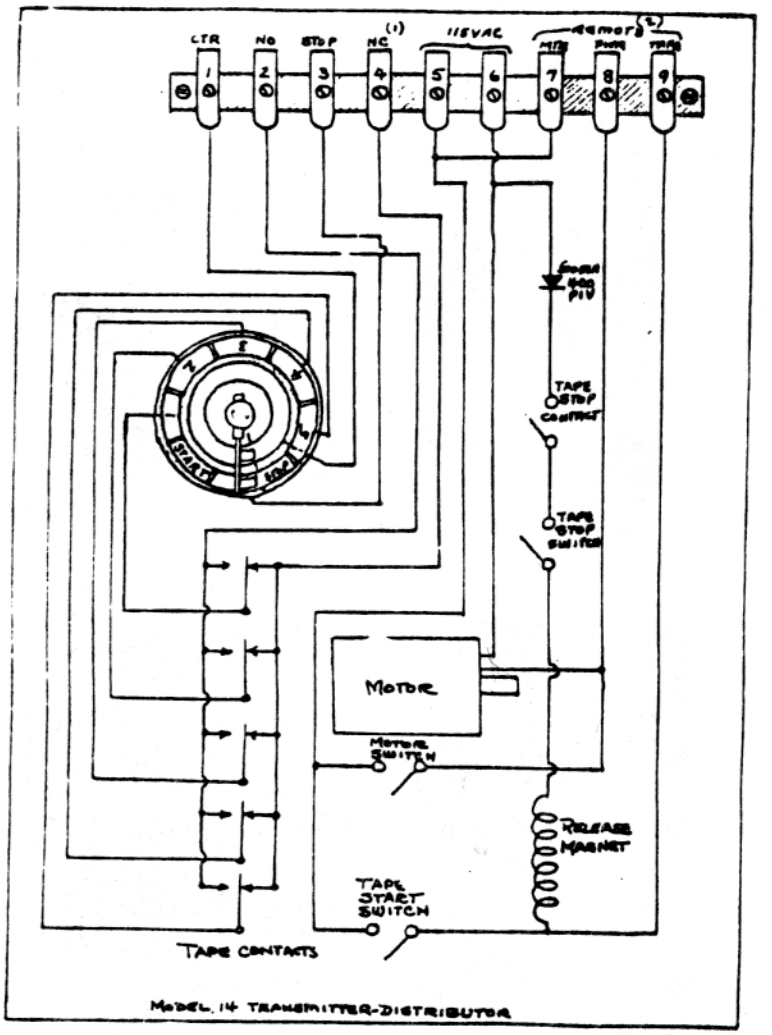
In the model 15, the paper is held on a roller which does not move back and forth as in the model 24 and 26s. The type basket travel from left to right a copy is received.

The range finder is located on the left hand side of the printer, and can be adjusted, when necessary, through a small door on the left side of the cover.

An "unshift on space", cut out or in, lever is provided under the front of the printer. See photo for location of this feature. Man DX RTTYers will find this feature to be of advatage in copying weak signal, especially when a static pulse operates the shift to upper case. It can be cut out by shifting the lever to the other position.

Also the keyboard can be replaced with a 15 perforating keyboard, which makes the 15 similar to a 19 unit. This requires a power supply which will provide 500 mils at 110 volts





(1) NOTE- NORMALLY CLOSED CONTACTS ARE THOSE IN CONTACT WHEN DISTRIBUTOR BRUSHES ARE ON SEGMENTS 1 THRU 5 (NOT STOP OR START) WITHOUT TAPE IN GATE.
(2) NOTE- TERMINALS 7,8 & 9 ARE FOR REMOTE CONTROL OF MOTOR AND TAPE START FUNCTIONS.

DC. The base casting is slotted for this modification.

The complete model 15 is made up of the following major parts: Base, with wiring; keyboard which plugs into the base; motor with electrical connections which make, when the motor is bolted to the base; printer, which contains all of the selecting and printing functions; a cover which completes the unit. Additionally,some of the 15s have a polar relay-socket mounted in the rear, others have an additional relay which controls the motor from line current. Other type motors can be had to operate from generator AC supplies or DC. Other type faces can be purchased to covert to weather operations. To mount the type faces soft solder is used, which permits one change the fraction pallets quite easily. Key tops can be changed by lifting at the top of the keys and pulling up, to replace, reverse the operation. Normal amateur operations are at a speed of 60 WPM, using gears which have numbers 74912 and 74913. However, speeds of 75 WPM can be had for other uses.

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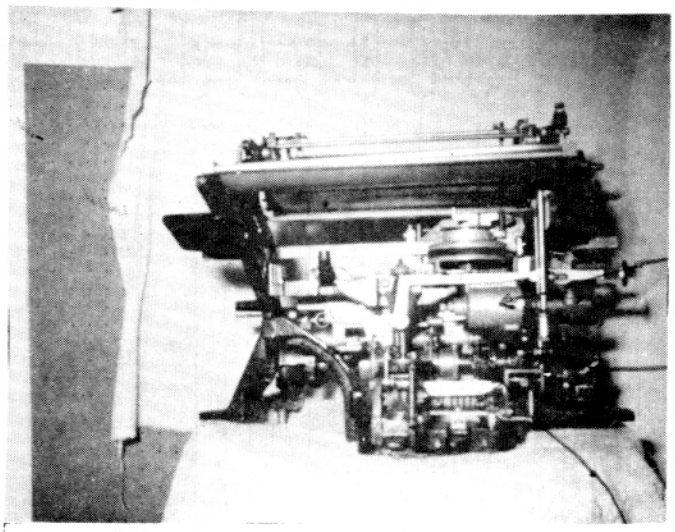
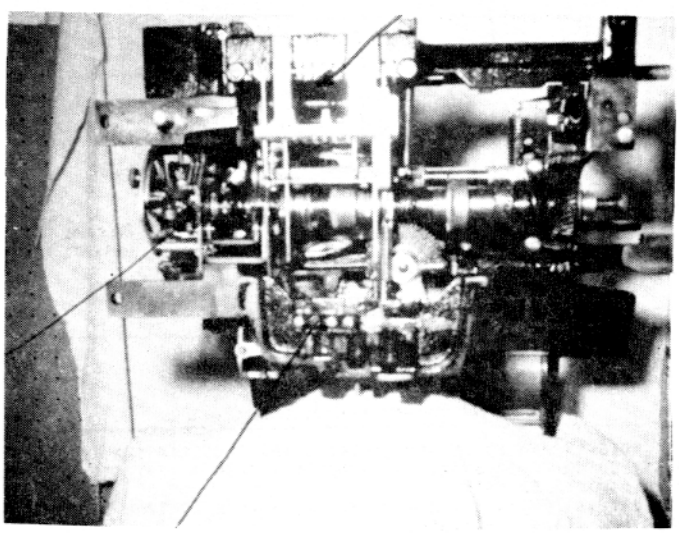
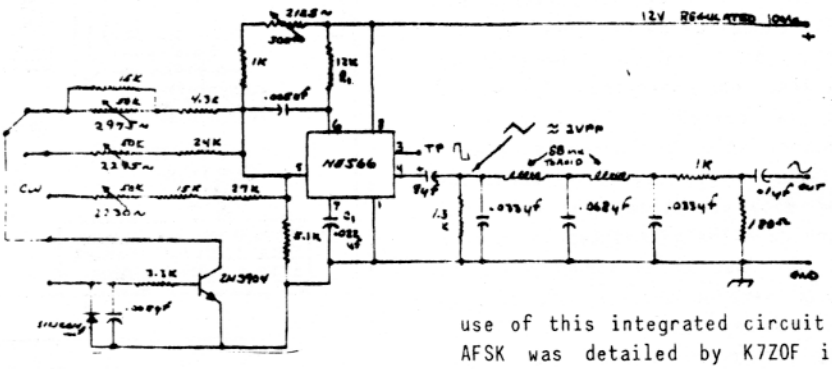




MODERN AFSK OSCILATOR

Donald Kelly, WAØTJR
1490 Yaqui Dr.
Florissant, Mo. 63031

My quest for a simple, reliable, and inexpensive AFSK was solved by the discovery of the Signetics function generator--the NE 566. The first



use of this integrated circuit as an AFSK was detailed by K7ZOF in Ham Radio of March '73. After reading his article and the Signetics application notes, I decided to design my own with the circuit results shown.

This unit costs about $10 to build. It produces stable sine wave outputs for the purest, but the filter can be removed if a triangle modulation waveshape is acceptable.Total current consumption is 10 Ma at 12 volts. The total part count is 29 versus 54 in the AK-1. The reliability of the unit has been fine. After a month useage (I leave my transistor gear on 24 hours a day 7 days a week), there was no shift in frequency.

The NE 566 is a voltage controlled oscillator. The basic frequency is set by R1 and C1 and then modulated (FSK'd) by shifting the voltage on pin 5. A well regulated source of voltage is essential. One of the three terminal regulator IC's will handle both the TU and the AFSK.

The parts are those in my junk-box. None are critical. The filter needs 1.2K terminations and there is no difference between mark and space tone amplitudes at the output. The resistance ratio was chosen to match the output of my Heath mike. All resistors are 1/2 watt carbons since they carry nill current. The pots are single turn cheapies and you can hit the frequencies on the nose with the values shown. The 2N3904 needs plus 12 on space and plus 2 or so on mark.

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This is enough to raise some eyebrows, but let's be more specific. Would you believe excellent copy on 170 shift and stability so precise that unattended auto start is easily accomplished.

The above is how my article started when it was published in the RTTY Journal back in December 1967. A number of changes can now be added to this original article. W6FFC Irv Hoff's XT-4 crystal oscillator will be incorporated. And WØKXZ Jack Headley's article on the conversion from 15 to 20 meters will also be included.

The unit we are talking about is Heath kits HW 16 Novice 3 band transceiver. The receiver contains an RF amplifier, hetrodyne mixer, crystal controlled hetrodyne oscillator, bandpass coupler, variable VFO, VFO mixer, crystal filter, if amplifier, product detector, crystal controlled BFO, and 2 audio amplifiers; sensitivity, less than 1 microvolt for 10 DB signal-pulse-noise to noise ratio; selectivity, 500 cycles at 6 DB down.

Sounds like a winner for 170 cycle shift, but there are some problems. First apparent thing is that the BFO crystal comes out on the wrong sideband and not in the center of the passband for 170 cycle shift. This must be changed.

Computations for determining crystal frequency for the receiver section, thanks to W8SDZ Keith Peterson.

Assuming that the half-lattice filter operates as they normally do, the center frequency will be half-way between two crystals, this is 3395.300 Kcs. When working with RTTY, it is easier if you convert everything to center frequencies. For instance the 3637.500 Kcs. channel is a center frequency of 3637.415 Kcs.

3637.500 KHz (desired receiver frequency)
-0.085 KHz (.085 KHz is just half of 120 cycles)
3637.415 KHz (desired receiver center frequency)

HEATHKIT TRANSCIEVER
9045.00 KHz (high frequency oscillator)
-3637.415 KHz (channel center frequency)
5407.585 KHz (first IF frequency)
-3395.300 KHz (second IF center frequency)
2012.285 KHz (second heterodyne osc. "VFO")

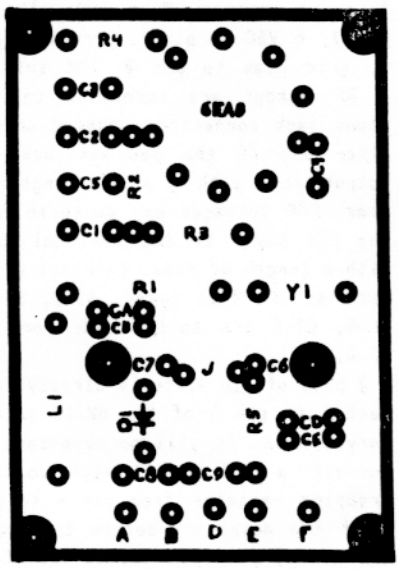
The desired audio center frequency
2125 Hz
+ 85 Hz
2210 Hz

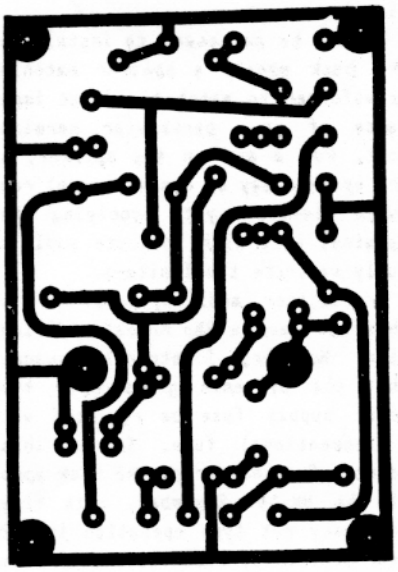
FOR HEATHKIT
3395.300 KHz (second IF center frequency)
- 2.210 KHz (audio center frequency)
3393.090 Khz (VFO crystal frequency)

Using the center frequency approach is possible because you know that you have plus or minus 150 cycles bandwidth (at IF) on either side of it. It is therefore possible to state: For the Heath Kit HW-16 CW transceiver and the 80 meter auto start frequency, one would need a 2012.285 Kcs. crystal to replace the receiver VFO, and 3393.090 Kcs. crystal to replace the present receiver BFO crystal.

To crystal control the receiver, it is necessary to disconnect the variable receiver condenser at point "X" on the receiver printed circuit board (this eliminates L-7, C-55, C54 and C-53 from the circuit). Using the vacated hole at point "X" on the P.C. board as one hole for mounting the crystal, drill another hole in the P.C. board so that the crystal can be mounted from point "X" to ground. Solder this crystal in the same manner used to mount the other crystals on the P.C. board. If you desire to use crystal controlled receive on 3675.500 KHz., use a 2012.285 KHz. crystal. If the frequency needs pulling one way or the other to zero a few cycles, you may adjust the frequency by varying the tuning of L-6 on the P.C. board.

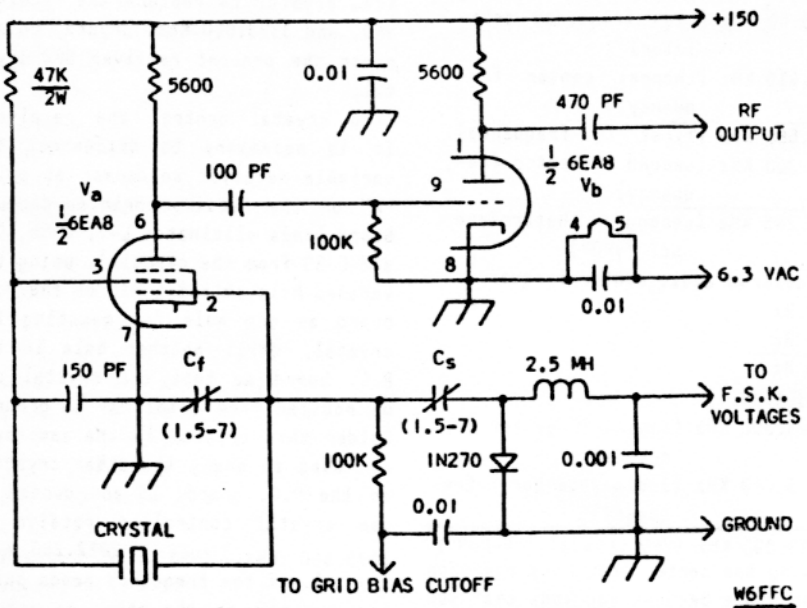
The side tone that is built into the HW-16 must be disabled. Disconnect one end of the neon lamp associ-





Y1-Xtal
CA, CB, CD, CE - padders
D1-1N270
A--150VDC
B-FSK voltages
D-RF output
E-Grid bias cutoff
F-6.3 VAC
J-Jumper
R1-47k 2 Wt.
R2, R3 - 5.6 K
R4, R5 - 100 K
C1, C4, C9 - .01 uf
C2-470 pf
C3-100 pf
C5-150 pf
C6, C7 - 1.5-7 pf piston
C8-001 uf
L1-2.5 mh

Parts & Placement for the WA8NGJ board.



THE MAINLINE XT/4 CRYSTAL RTTY OSCILLATOR

ated with the side tone generator to accomplish this. By removing the side tone function, the receiver will be capable of monitoring the transmitted signal.

It may be necessary to install, on the back panel, a speaker matching transformer to match the input impedance of your particular terminal unit. Put a pad on the speaker, so the speaker may be run at normal room audio levels, yet supplying the terminal unit with adequate audio to fully saturate the limiters.

Transmitter modifications: So far this has been a "No Holes" modification. However, I strongly suggest that the Sylvanin grasshopper type power supply fuse be replaced with a conventional fuse. To do this, mount a fuse holder on the back apron of the HW-16. Remember, this fixed frequency net type operation is a 24 hour unattended business and if something goes wrong, the grasshopper fuse will open, and when cooled down, reset, open again, etc. until it is discovered that something is wrong. This may be too late, as it happened to me after 6 1/2 years of continuous operation where darned near everything melted.

The XT-4, Irv Hoff's crystal oscillator, which has been reprinted here, may be built into a small Bud mini-box with an octal plug mounted on one end of the box to match the octal accessor socket on the HW-16 in the following manner. Plus 150 volts to pin 7, 6 VAC to pin 2, ground to pin 1, grid bias to pin 8, FSK voltage & RF output are connected to two phono jack connectors mounted on the other end of the Bud mini-box. RF output jack with a short length of coax. FSK voltages may be taken from the FSK keyer in the terminal unit with a length of coax. Terminal units such as the TT/L types, ST-3, ST-4, ST-5, ST-6 are tailor made for the XT-4.

B plus of 310 volts is already connected to pin 4 of the HW-16 accessory socket. It will be necessary to connect a 10K ohm 2 watt voltage dropping resistor from pin 4 to pin 7 of the accessory socket to supply the needed plus 150 VDC to the XT-4.

WA8NGJ, Doug Williamson, has designed a printed circuit board for the XT-4. This will simplify the construction of the unit and has allowed us to reprint his layout here, showing both the foil side and parts replacement. This will enable the builder to reproduce this board easily. The board may be mounted on the top side of the bud mini-box, or be mounted on the inside of the HW-16, as will be shown in a 20 meter conversion article later.

Rapid switching may be accomplished at a remote location such as a switch on the keyboard of the printer. This switch would short the key jack located on the back apron of the HW-16. When closed, it will automatically actuate the transmitter and simultaneously mute the receiver by means of the automatic switching designed into the HW-16.

A note should be made about true transceiver type operation. Most transceivers use portions of the receiver and portions of the transmitter for dual function purposes, therefore it is impossible to tell exactly what your transmitted frequency is. The HW-16 is a completely separate receiver and transmitter. If you desire, you may leave the receiver connected to the input of the terminal unit and monitor your transmitted signal on the terminal unit scope.

Those interested in the theory behind the XT-4 crystal oscillator are encouraged to read Irv Hoff's article published in December 1967 RTTY Journal.

CONVERTING THE HW-16 to 20 METERS

Converting the receiver and transmitter to 20 meters

Mechanical stability

Receiver AVC

Internal mounting of the XT-4

Front panel receiver vernier tuning.

Following is a Crystal Chart of the more popular auto start net frequencies.

HW-16 Receiver Crystal Frequencies

	80 METERS		40 METERS		20 METERS	
Operating freq.	3637.500	3617.500	7137.500	7117.500	14,082.500	14,075.000
Receiver osc. xtal	2012.285	2032.285	2012.285	2032.285	2 067.285	2 074.285
HFO xtal	original	original	original	original	19,545.000	19,545.000
BFO xtal	3393.090	3393.090	3393.090	3393.090	3 393.090	3 393.090
XT-4 xtal	3637.415	3617.415	7137.415	7117.417	7 041.200	7 037.000

Converting the receiver section of the HW-16 from 15 to 20 meters. Remove the 26,545.000 kHz 15 meter HF oscillator crystal. Replace it with a 19,545.000 kHz crystal. Install a 10 pf mica capacitor across L4. With the aid of a grid dip miter, tune L4 to 19,545.000 kHz. Remove L1, unwrap the old windings and rewind the coil form with 12 turns of number 22 enamel wire. Reinstall L1. With the aid of a grid dip meter, tune the coil to 14 MHz. Install the appropriate desired receive frequency crystal from point "X" on the receiver P.C. board, to ground. Refer to Part I in the July 1974 RTTY Journal for the procedure required to calculate this crystal frequency, also refer to the "Popular Net Frequencies" chart to be sure that you are in the right ball park.

Converting the transmitter section of the HW-16 from 15 to 20 meters. Install a 20 pf mica capacitor across L9. With the aid of a grid dip meter, tap on L16 (final tank coil) 3 turns up. The transmitter doubles to 14 MHz and 7 MHz crystals are used in the XT-4 for operation on that band.

You may desire to stop at this point; however, some instability is inherent on 20 meters. This condition is both mechanical and electrical.

Most of the mechanical instability is the result of the light hook-up wires connected to the band switch. I would suggest that this wiring be replaced with a heavier bus bar.

Electrical instability is primarily due to the unregulated voltages at the receiver oscillator stages. Install a VR150 voltage regulator tube and socket in the front outer corner of the HW-16 receiver section. The center of the VR150 tube socket should be 1" from the right hand edge of the chassis and as close to the HW-16 receiver P.C. board as possible. This will allow adequate room to install the XT-4 piston trimmers on the front panel. Solder a one lug terminal strip on the circuit board foil on the ground bus near point "P". Connect a wire from this lug on the terminal strip to pin 5 of the VR150. Remove R31 from L6 to point "P" on the circuit board. Connect a 5600 ohms 1/2 watt resistor from L6 to the terminal strip. Connect a 4500 ohm 10 watt resistor from the terminal strip to point "P" on the circuit board.

Receiver AVC may be added by using a CK1121 Raytheon Raysistor. The socket which is supplied with the CK-1121 may be mounted in any convenient place on the back apron of the HW-16. Hold the socket with the pins up and the two close-spaced pins away from you. Number these two close-spaced pins, 2 & 3, the left hand lower pin number 1 and the lower right hand pin number 4. Pins 2 & 3 are grounded. Pin 1 is connected to pin 2 of V6A on the HW-16 receiver P.C. board. Connect pin 4 of the Raysistor to pin 1 of the phone jack from the audio output of transformer T4. Remove R70 (10 ohms) from the audio output transformer T4.

Internal mounting of the XT-4. As described in the July 1974 RTTY Journal, the XT-4 may be built either on a small P.C. board, or hand wired. In either case, the most convenient spot to mount the XT-4, is at the present location of the receiver VFO capacitor (C53).

If you are using the P.C. board, remove the receiver VFO tuning capacitor and either move or remove the adjacent dial light and associated parts. Using 1/2" metal spacers, mount the P.C. board to the metal chassis above the vacated area of the VFO capacitor. Remove the two JFD glass piston trimmers from the P.C. board and, using insulated hardware for the one trimmer that is above ground, mount the two trimmers on the front panel of the HW-16. This will permit easy access for the fine adjustment of both mark and space frequencies of the XT-4.

Using the hand-wired mounting for the XT-4, remove the receiver VFO capacitor. Mount a tube socket for the 6EA8 tube and associated terminal strips needed. Mount the JFD trimmer capacitors on the front panel of the HW-16 in the same manner as used in the P.C. board mounting. The only difference is that the trimmers will be mounted below the main chassis of the HW-16.

Obtain your plus-150 volts from the now regulated plus-150 volts VR150 voltage source. The RF output is connected to pin 2 of V7 on the HW-16 receiver P.C. board. Mount an RCA phone jack on the back apron of the HW-16 to bring in the FSK keyer voltages to the XT-4. Grid bias cut off voltage for the XT-4 may be picked up at point "Y" on the HW-16 receiver P.C. board. 6.3 VAC may be picked up on pin 3 of V4 on the HW-16 receiver P.C. board.

Now that you can tune the XT-4 from the front panel of the HW-16, mount another 1.5-7 pf JFD piston trimmer next to the two already mounted on the front panel of the HW-16. Connect this trimmer to point "X" on the HW-16 receiver P.C. board. You now have a small vernier padder across the VFO replacement crystal, which will allow you to zero the crystal to the desired frequency and will also allow you to peak the coils of the receiver in accordance with the Heath Kit manual.

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HW-16 Conversion, Boerkoel, RTTY Journal Dec. 1967.
XT-4 Crystal oscillator, Hoff, RTTY Journal Dec. 1967.
HW-16 20 meter conversion, Headley, RTTY Journal June 1968.

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RTTY OPERATING PROCEDURES

GETTING STARTED

Operating procedures and customs differ on RTTY as with other modes. Legal identification by readable CW is required by law. Other customs and habits are determined by the operator and to some extent by the equipment in use. As a suggestion to beginners, the following procedures are listed.

CW IDENTIFICATION

Your call (only) must be sent on READABLE CW at the beginning and end of each transmission. As on other modes, stations breaking back and forth may omit this identification as long as it is given at least every ten minutes. No station identification is required from the printer but it is usual to give it at the end of each transmission as a courtesy to other stations listening. It is not necessary (or good practice) to print "CW Id to follow" at the end of any

transmission.

CALLING A STATION

Zero his frequency-CW ID - then call similar to other modes. Be sure to repeat your call several times as this gives the other station a better chance to get your call correct.After a QSO is established, a single call is enough or just a BK.

CALLING CQ

Please keep them brief. A whole line of CQs across the paper is an invitation for a station to look elsewhere. Send 3 or 4 CQs and then your call at least 3 times and repeat for several lines and then LISTEN. If no answer, repeat for several times. Any experienced RTTY operator can recognize a CQ by ear but not your call, so be sure to include it a number of times. Many like to include their name just before signing. AND be sure you listen to the frequency for other stations before starting.

BREAKING IN A QSO

Wait until the CW ID of the transmitter station is finished - give your CW ID and then BK de(your call). It is not necessary to give any or all of the calls of the other station now. If acknowledged, make a short transmission or ask a question if you have one and then turn it to the next station in the group.

TYPING

Unfortunately, many of us are not good typists and a beginner is also very apt to be nervous. Do the best you can, most RTTY operators can remember their first attempts and are very tolerant. If you are a slow typist, help speed things up by economizing on words, no need to apologize or explain that you are slow - he knows it by now anyway. Give him your name - location or anything else of interest. Abbreviate words when possible, such as CW operators use. Practice when you have a chance, and you will soon pick up speed. If you have a TD (Tape transmitter), make some tape while the others are printing, and when your turn comes, you are all ready for a fast answer.

TECHNICAL TYPING HINTS

Today there are many different types of printers in use, many with various automatic devices for giving automatic carriage returns, line feeds etc. However, you can not go wrong with the following sequence at the end of each line (72 characters or less). TWO CRs, one LF and one Ltrs. The 2 CRs make sure that one is received and starts the carriage returning, the LF turns up another line and the Ltrs gives a little time for all this to happen as well as making sure the machine is in lower case. This will work with about all machines including those with automatic features. Most machines are fixed to return to lower case on a space, if sending numbers or upper case remember this and hit the FIG key after each space or use the dash instead of a space. Stations using a video printer prefer none of these functions as it is done automatically and with a shorter line much space is lost with CRs inserted. If you are in a group, however, with regular printers as well as video, use the regular procedure to prevent confusion on the regular printers.

COMMENTS

RTTY has a fine bunch of operators. If you are a beginner and are puzzled by something - ask - if possible, I am sure you will get help. Most terminology on RTTY is similar to other modes. "73" means best wishes or regards. 73-73-73 means "best wishes - best wishes - best wishes." Choose the one you like best. Likewise, "HI" is used to denote humor of some kind in the print just sent or received. We have never been sure but suppose that "HI-HI-HI" means a big guffaw, and frankly, we have seldom been affected that way over the air. One "HI" should be plenty and unless you are Bob Hope, not too many of those. Be natural and print the same way you would talk to a person.

CONCLUSION

In spite of this long column on "do's and dont's, RTTY is a lot of fun. Usually it is easier and more fun if done the accepted way but every person is entitled to his "own thing" and this applies to RTTY also. HAVE FUN and good printing.

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PICTURES ON RTTY - HOW TO MAKE YOUR OWN

One phase of RTTY that is of interest to a large group, is the transmission and reception of RTTY pictures, QSL cards, and even poems or quotations are popular items. Tapes of most of the popular items are available from several sources. Best of all, you can make up your own art work and then exchange it with others. Don Royer, WA6PIR is probably the outstanding creator of this work, and his article on how you can do your own is included here. The illustration is just a sample of a few of the pictures all made by amateurs.

Don Royer, WA6PIR
16387 Mandelay
Encino, CA 91436

A few years ago, you were asked if you had ever wished you could create RTTY art. It is still a great deal easier than you might think.

There is much basic art work available from which RTTY pictures may be made. Comic strips, magazines, newspapers, gatefolds, photographs and copies of works of art may all serve as bases for pictures. While these may not be the right size, an inexpensive child's pantograph or some types of Xerox machines may be used to enlarge or reduce them. A portrait of Washington was made from the etching on the dollar bill. Also, if you have a little sketching talent, that will help (or enlist the help of your wife and friends). Be sure to keep your left and right margin distances in mind when sizing your art and in selecting protions of large basic material. Remember that the width limits of most teleprinters will permit a picture of only a little over seven inches wide.

After selecting your subject and

sizing the art work, run about four feet of paper from your printer. Use the center protion and carefully tape or glue the drawing or photo to the paper. Trim the edges to the same width as your paper. Now remove the paper stock from your printer and insert the four-foot sheet whereby the sketch is presented to you as it rolls over the platen. Carefully align the edges of the paper on the platen. Use your line feed to bring the top of the sketch into view. You are now ready to type the first run of your proposed picture directly upon the sketch, punching a tape as you go.

A small selection of characters is all that is needed to produce either outlined or shaded pictures. Study the letters and other characters to learn their individual densities. For example, the M and W are the darkest, followed by the H or X and then by the I. Thereafter, you can use the upshifted characters such as the : or ; followed by the " or - or . and the like, depending upon where you want the print to fall. In this way, you may add the shading that you desire or leave certain areas blank like this:

MMHMHHHHII:I::.:.'

.'.:.::I:IIHHHHMHMM'

going from dark to light and back to dark again. Due to their shape, you may also desire to use the V, A, F or L at the beginning and ends of dark areas to obtain smooth lines and perhaps accompanied by an apostrophe or period. With a little practice, you will be able to tell just where any character will strike the paper. Do leave blank or white areas whenever possible and don't try to fill the entire line with characters since this is a black and white (hopefully you have white paper) picture and you must rely upon the contrast to produce the desired detail. Continue the typing process over the entire sketch.

Now remove the sketch from your printer and reinsert your paper stock. Play out the tape you have made. You will probably be pleasantly surprised. Use a red pen to indicate on the print where additions, corrections and any changes are to be made. Rerun the tape (having folded the marked-up print and following it line-by-line using the paper holder and line guide on the printer) to make corrections, punching a new tape at the same time. In most instances, a good picture may be made with a series of five or six correction tapes.

When typing on the sketch, it helps to have a strong light directed onto the sketch in your machine. This is particularly true if the contrast of the sketch is poor, as may be in color photos. Also, since your will be unable to see the part of the sketch below the ribbon, a pencil may be used to outline the areas where the shading will change from one density to another. You may thus be able to produce a more complete picture the first time thru. Some of the RTTY artists have found that it helps to make Xerox prints of the original sketches or photos and to use those for their art work, as this eliminates some shading and provides a black and white format from which to work.

Keep the detail of the original art work as large as you can and don't be afraid to experiment with different letters and techniques. Do clean up your tapes. This may be done during the first run-thru after the typing to remove any extra characters that crept in by mistake. To give you some idea of the time required to complete the pics, about 20 hours is needed for one of the playmates that runs 30 minutes or so. Most of this will be in making the corrections and in rerunning the tape. Even after they are apparently finished, hang your creation across the room to see how it looks from a distance and then make a final tape with the finishing touches, increasing or decreasing contrast in certain areas and cleaning up edge lines. Time and patience!

As many modern machines have non-overline features, it is generally well to avaid overline printing.Good, non-overlined pics may be made by using the various character densities to create desired contrast. Stay within a 72 character line. Start and end the tape with a series of LTRS or blanks, a single carriage return and about ten line feeds. Keep in mind those machines which downshift on space as well as those which do not. If you are upshifted, and then space and wish another upshifted character, put in another FIGS character. Of course, the same applies when you want a letter following a

space after an upshifted character and another LTRS must be added. At the start of each line, use one carriage return, the line feed and on LTRS unless the first character of that line is upshifted and requires a FIGS.

Again, make your tapes as short as possible by taking out any unneeded characters, extra LTRS, FIGS followed by LTRS and things like extra spaces or LTRS at the end of a line. Above all, be sure to put your credit line at the end, with the hope that others will follow your lead and keep it there.

There is one further situation you may wish to consider. An increasing number of machines do not use the standard communications keyboard. On these machines, the apostrophe and the bell are switched from the more normal arrangement of the apostrophe over the "J" and the bell over the "S". To enable the pictures to be printed on either machine, it is only necessary to use both of these characters. That is, every time you use an apostrophe follow it immediately with a bell. This, of course, will produce a lot of bell ringing during reception but will enable full and accurate print on either type of keyboard arrangement. Most of the commercially available picture tapes are formatted in the suggested manner.

If you make or obtain pictures that are in several panels, it is very important that your paper is very tight on your platen. Otherwise, the panels will not line up. In putting these panels together, trim the border from the left edge of the second panel and carefully align it with the appropriate edge of the first panel. You may have to compensate if the print is off a bit. The panels may be secured together with plastic tape or, better yet, with a small amount of white glue. For wall display purposes, if your paper is thin, the overlapped areas may be hidden by backing the finished print with black paper.

So if RTTY pictures excite your imagination, how about trying your hand at making at least one? You may find some hidden talent.

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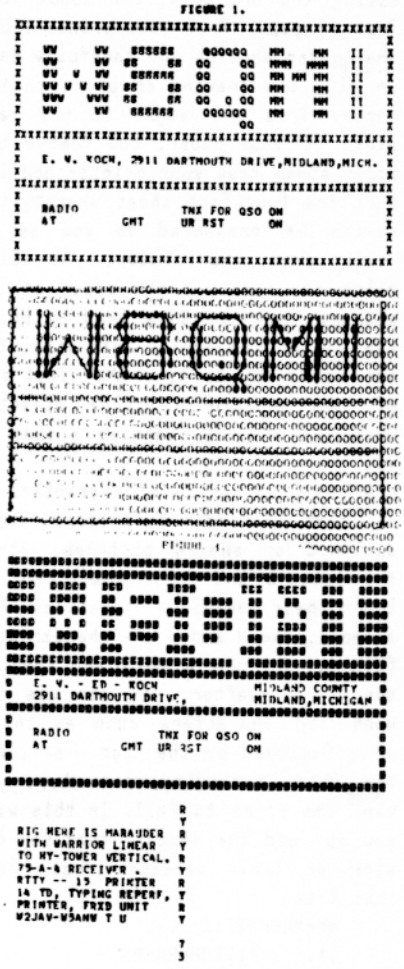
RTTY TAPE - ART AND MUSIC

In spite of the fact that more and more RTTY tape gear is being used on the air nowadays, its use seems to be limited to the customary "CQ" tape, a simple "brag" tape, and the taping of answers in a fast QSO. Perhaps the disappearance of QSL cards and similar tape art is because so little, if any, has been written about the procedures for preparing tapes. In the hope of encouraging you to "do it yourself", this article was written. Equipment needed is a printer, a typing reperforator, and a tape distributor--or their equivalent.

The foremost RTTY artist (who made up those wonderful portraits of the Presidents) prefers to make up his preliminary sketches on graph paper. Since few households have a ready supply of graph paper, a much similar approach is to print up a page, or the desired part of a page, with the letter "O". You can do this by hand if you need the exercise, but it is better to make an endless tape loop to automatically print the "O"s... start the tape with 3 letters shifts, a carriage return, a line feed, 70 "O"s, and 3 letter shifts. Splice the tape by gluing the 3 letter shifts perforations at the end of the tape of the 3 at the beginning. What glue to use on the oiled tape? An expert in office tape machines told me that "Elmer's White Glue" (R) is the best possible material for the purpose--so much so that his company did not market its own glue for tape splicing. Use a very small amount of glue and carefully match the tape perforations. The tapered point of an ice pick is a help here. Check for straightness by setting the tape loop on edge on the table top--if it lies flat all the way around, it is straight. You have a minute to make a slight adjustment while the glue is setting.

As an example, let's start out to make a tape for the QSL shown in Figure 1. Put the "O" tape in the tape distributor and use it to print a block of "O"s a little larger than the desired form. A nicety is to use a well-worn ribbon on the printer so that the "O"s will be just visible.

FIGURE 1.



Now roll the paper out of the printer and tear it off, leaving a generous top and bottom border. Take a soft lead pencil and sketch the desired design, using the "O"s as a spacing guide, as shown in Figure 2. Now put your sketch back into the printer; carefully realign it so that the typing you are about to do will exactly coincide with the "O"s previously printed by the tape. Replace the worn ribbon on the printer with a good, black one. Start up the printer and reperforator, and type in the desired pattern and lettering, using your pencil sketch as a guide. To check your accuracy, run the tape through the tape distributor and print the results. Usually you will find two or three errors at this point; mark them so you can readily see them, and make a new corrected tape.

In making new tapes from old ones, I find it very handy to have a switch located alongside the printer keyboard--this switch is connected across the signal output of the tape distributor. When you come to a point on the tape where deletions are necessary, just throw the switch to the shorting position, type in the correction, advance the tape to the point where you wish to copy it again, stop the tape, flip the shorting switch off, and you are ready to resume copying. You will be disappointed to learn that the switch cannot be used "on the fly"--this results in misprints, ruining the new tape.

One part of the QSL shown in Figure 1 requires special treatment; the part calling for the filling in of data--the other fellow's call, RST, time, date, etc. The QSL tape is punched so that it types the entire line, including the right border, followed by a carriage return without a line feed, followed by the number of spaces needed to put the carriage at the point where the call is to be typed in manually. At this point, the tape should have a bell signal followed by 8 to 12 letter shifts, ending with a carriage return and a line feed. The same technique is used on each of the other lines where data is to be typed in manually. In transmission, then the procedure is to listen for the bell. When it sounds, quickly turn off the tape advance, manually type the entire line of data, and then without using the carriage return or line feed, turn on the tape advance and wait for the next bell to signal. For the line where you are to type in the time of QSO, you may prefer to use figure shifts instead of letter shifts--it saves you punching the figure shift key manually--but if you do, be sure to include a letters shift at the end of the series.

This may be a good time to mention the matter of excess carriage returns. I started out in RTTY with a model 26 that never could quite get back to the left margin in time to properly print a tape-transmitted signal, so I got the habit of always inserting a few extra carriage returns on my tapes to make sure the printer had time enough to print properly. Now I learn that some of the fabulous 28s have an arrangement to line feed each time they receive a carriage return--and a friend of mine sent me a page of copy to show how I was wasting his paper, hi! So watch those carriage returns for the sake of your lucky friends.

Now that we have struggled through the first QSL, it won't be necessary to start from the very beginning on the one shown in Figure 3. The trick here is to take a copy of the QSL of Figure 1, put it back in the printer, and then carefully type a line of "O"s to cover the open spaces only, followed by a carriage return with no line feed and an over-printing of "X"s. Note that this new QSL has an added feature--a place for name and address, as on a postcard. When you run out of your printed QSLs you can easily run off a RTTY QSL card. The data can be filled in on the printer or with pen or pencil. Crease the copy at the bottom of the design and paste it to a 4" x 6" file card. After the paste hardens, trim the card to size, and it is ready for mailing.

For the RTTY contest man, the following should prove helpful. The first of two tapes is used in the situation where you have been calling "CQ Contest" and a station answers you. You manually type his call several times and then use the following tape:

(no carriage return or line feed)
de W8QMI THANKS OM FOR THE CALL PSE QSL MY NR UR RST DATE-TIME BAND SECTION carriage return, line feed, signal bell, and 8 to 12 figure shifts, and a letters shift) (end tape). When the bell sounds, stop the tape advance, manually type in the data below each heading, using dashes or periods between numbers to avoid shifting.

The second contest tape is used in the situation where the other fellow has called "CQ contest" and you are answering him. When he returns, giving his text, use the second tape (similar to the first one,except for the headings which are as follows:

QSL UR NR UR RST DATE-TIME BAND PSE QSL MY NR
FROM MICHIGAN SECTION BK BK

In use, the contest tapes should be clearly marked with a heavy lead pencil to avoid mixups in operation. They can be endless, but I prefer to have them repeated several times on a strip. If you are a slow typist, you can include considerably more routine material--"thanks for the contact, hope you have good luck in the contest, name here is Ed, etc., etc., and for any other contest call." Use of these tapes makes for extremely rapid operation and assures you of transmitting all necessary contest data on you first transmission. If things are rough, you may want to make a reperf of your transmission so you can repeat it completely by using the reperfed tape.

Music on RTTY? Percussion is probably a better term for it. I am sure you have all heard that old refrain "Shave and a haircut" banged out on the bell signal, but I wonder if you have ever tried to do it on tape? Try this ("F" indicates a figure shift, "S" is the letter "S"):

FSFFFSSSFSFFFSFFS

If you are musically inclined, the basis for this is as follows:

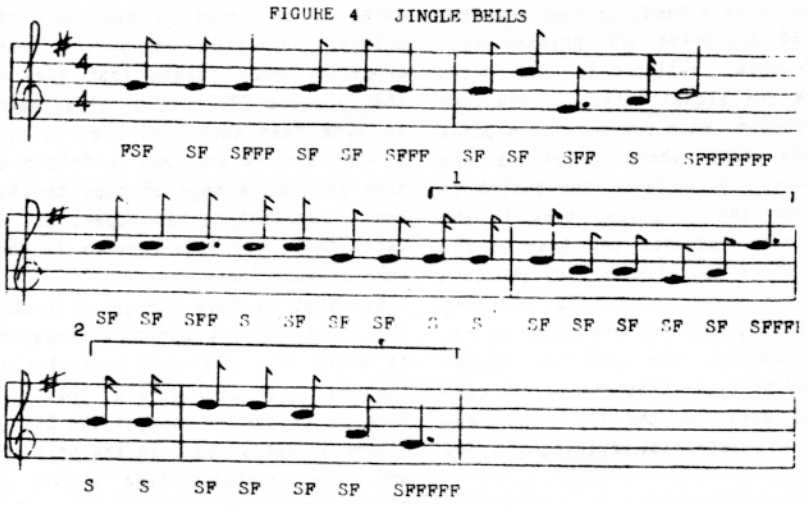
one half note
bell and seven shifts
one quarter note
bell and three shifts
one eighth note
bell and one shift
one sixteenth note bell

Figure 4 shows the application of this to "Jingle Bells", which you may want to try for yourself. A far more interesting and "hep" version gives it a catchy New Orleans jazz beat and combines with it the typing of "Merry Christmas and a Happy New Year to All". Its reproduction is tedious but worthwhile. The hardest part is keeping track of what you have typed and what comes next. In addition to "F" and "S" as above, now "X" indicates a letters shift, and "Z" a space. Spaces shown here between symbol groups are aids in reading only--do not include them in your tape:

Carriage return and line feed

FSFSFSXMFS FSFSXEFSFS
FSFFSSXRRY ZFFSFSFSFF
SSFSFSFSSS
FSFSFSFSXC FSXHFSFSFS
XRFSFSFSXI FSFSFSFFSS
XSTMASFSFS
FSFFSSFSFS FSSSFSFSFS
FSXZANFSSS FSFSFSFSXD
ZAFSSSFSFS
FSFSXZHAFS SSFSFSFSFS
FSFSFSSSFS FSFSFSXPFS
XPFSFSFSXY
FSFSFSFZFS FSFSFFSSXN
EWZYFSFSFS FFSSFSFSFS
SSFSFSFSFS
XEFSXAFSFS FSXRFSFSFS
XZFSFSFSFF SSXTOZALFS
FSFSFFSSFS
FSFSSFSFS FSFSFXL
Carriage return and line feed.

FIGURE 4 JINGLE BELLS



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AWARDS FOR RTTY OPERATIONS

There have been many Awards made available to the RTTY amateur over the years and what we have tried to do here is gather them all together in one place for handy reference. The collection may not be complete but are all those we are aware of at this time. As others become known or made available to the RTTY'er, we will add to the list at some future date.

We would also like to make you aware of the many fine Awa rds made available by the sponsors of the RTTY Contests that take place every year. They range from beautiful engraved Plaques, to gold, silver and bronze medals, down to really fine certificates for call area winners. Give it a try, you may be surprised how easily you may win one of them.

100 - DXCC - RTTY
"100 DX Countries Confirmed on RTTY"

The RTTY Journal will present the 100 - DXCC - RTTY Award to any amateur that produces proof of two way radioteletype contact with 100 different countries. The ARRL Country List will be the final authority as to what constitutes a country for amateur radio purposes and we would advise that those interested obtain a copy of "Operating Aid Nr.7", which is available from the ARRL.

There is no charge for the Award and it is in the form of an attractive engraved Plaque that any amateur would be proud to display. Once the Award is obtained, additional "endorsements", to be attached to the Plaque, will be awarded for additional countries contacted, in multiples of Ten (10).

Application for the Award is to be made in the following way:

1. Submission of 100 or more QSL cards along with a list of the countries claimed. These are to be sent to DX Editor, RTTY Journal, P.O. Box RY, Cardiff by the Sea, CA 92007. Registered mail should be used and sufficient return postage in the form of US funds or IRC should be included to have the cards returned in a like manner.

2. Less than 100 QSL cards with the balance of confirmations to be as follows. The Journal will accept written transcripts from any valid RTTY Contest Log when properly authenticated by the Contest Committee of the Society or Group running the contest, provided of course that both parties concerned submitted logs for the Contest concerned. Only contests held after January 1, 1972 will apply and it would be advisable to make such requests as soon as possible after the particular contest results are published, as we doubt that such records are held for more than a year.

QUARTER CENTURY AWARD

The Quarter Century Award (QCA) is issued by the British Amateur Radio Teleprinter Group on the submission of satisfactory proof of Two-Way RTTY communication with 25 different countries.

Measuring 10" by 13" and printed in Red and Green, the Certificate makes an attractive addition to any Amateur Radio Station. Endorsement stickers are available for each additional 25 countries.

Application for the Award may be made by the following methods:

1. Submission of QSL Cards for the countries being claimed. These cards are returned to the owner after checking. Alternatively, submission of Photostat copies or clear photographs of the cards. Such copies should clearly show the call sign of the Amateur making the claim and also establish the fact that the contact was made using RTTY as the mode of communication. This type of claim must be witnessed and signed as accurate by TWO other licensed Amateurs.

2. Claims may also be accepted based on a Contest Log submitted for any Contest sponsored by the British Amateur Radio Teleprinter Group. The

claim for the QCA Certificate should be made at the same time as the contest log is submitted.

Send your claims to:
Ted Double G8CDW
BARTG Contest & Awards Manager
89 Linden Gardens
Endfield, Middlesex, England.

ADDITIONAL NOTE: Holders of existing QCA Awards will automatically have any new additional countries added to their records when they submit Logs for any BARTG RTTY Contest.

W A S AWARD

WAS means "Worked All States". An amateur, anywhere in the world, who succeeds in getting confirmed contacts with all fifty U.S. States and sends them in for examination, may receive this Award from The American Radio Relay League, 225 Main Street, Newington, Conn. 06111. There is a nominal service charge to those amateurs located within the League's operating territory (U.S., possessions, Puerto Rico, and Canada) who are not ARRL members. For others, there is NO charge, except postage which is expected to accompany the cards.

You may make the contracts over any period of time and on any or all amateur bands. You may have your WAS Award issued for some special way in which you made it, in this case, ALL RTTY, only provided that all cards submitted plainly show that the contacts took place "2 x RTTY".

Before you send your cards, drop the ARRL a line requesting a copy of the rules and an application blank.

ALL STATE RTTY AWARD

The Florida RTTY Society issues an "ALL STATES AWARD" which is awarded to any RTTY operator for two way RTTY contact with all 50 States.

QSL cards confirming contacts must be sent to the Secretary by registered mail and sufficient postage must be included to return the cards by the same class of mail. There is no other fee involved. The ASA certificate is one you will be proud to own, and if you can qualify you are urged to submit to the Florida RTTY Society, Inc., 3039 Mango Tree Drive, Edgewater, Florida 32032.

WORLD RTTY CHAMPIONSHIP

This Award which is sponsored by the Italian Magazine "CQ Electronica" is organized in order to promote greater interest for the RTTY'er taking part in the various Contests during the period of one year.

At the present time, the Contests which provide scoring points towards this Award are as follows:

BARTG SPRING CONTEST
DARC WAE CONTEST
SARTG RTTY CONTEST
CARTG WORLD-WIDE RTTY SWEEPSTAKES
A. VOLTA RTTY DX CONTEST
GIANT FLASH RTTY CONTEST

The task of administering the CHAMPIONSHIP is shared between several of the RTTY Groups.

In order to arrive at the final score and to decide the winner, the following point system is used for each Contest: 30 points to the winner, 25 points for 2nd place, 22 points for 3rd place, 20 points for 4th place, 18 points for 5th place, 17 points for 6th place, 16 points for 7th place, and with one point less for each place to 22 for which 1 point is awarded and all other entrants will also be credited with one point.

For the final score each year, only the best 4 scores (out of a possible 6) of each operator will be used.

In order to take part in this Award it is not necessary for entrants to send in a claim as the entries of all competitors in all six Contests will be automatically included.

W A C - RTTY

This Certificate was originally conceived by the RTTY Society of Southern California and issued by the RTTY Magazine, predecessor to the RTTY Journal. It is presently issued by the DX Editor of the RTTY Journal and all requests should be sent to: P.O.Box RY, Cardiff by the Sea, CA 92007.

In physical appearance it is very similar to the regular/WAC Certificate as issued by the IARU, both as to size and format. The requirements are that you submit proof of two-way RTTY contact with the six Continents--North America, South America,Europe, Africa, Oceania, and Asia. There is no charge for the certificate and it is forwarded via 1st class mail. Postage to cover mailing and return of your cards is very much appreciated.

To make it somewhat easier for Amateurs in remote areas to receive the Award and to minimize loss of cards in the mails, we have at the present time a working arrangement with the Contest and Awards Managers of BARTG and SARTG for verification of WAC-RTTY. If you enter one of the annual Contests sponsored by the above groups, you may, at the same time you submit your log for the Contest, put in a claim for WAC if this had been accomplished in the course of the Contest. If the other stations submitted logs and claims is verified by the Contest Committee, I will be notified in writing and the Certificate will be issued. This service is not retroactive and must be done at the time the Contest log is submitted.

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RTTY FILTERS FOR AMATEUR TU's

FILTERS FOR AMATEUR TU's
Grant E. Storey, W6NTK
P.O.Box 426
Oakhurst, California

For some time, many amateurs have asked for sources of good filters or sources of toroids. For some, Jack Pitts, W6QK took care of requesting for such items. But with his QSYing to YV5 land, we are fortunate in having Grant Storey W6NTK take over with some excellent filters and tuned toroids. Shown below are the various filters he offers. For those who do not have a good Audio Oscillator and a vacuum tube voltmeter, here is a good place to get those filters.

RTTY

FILTERS FOR AMATEUR TU's

FILTERS FOR AMATEUR TU'S
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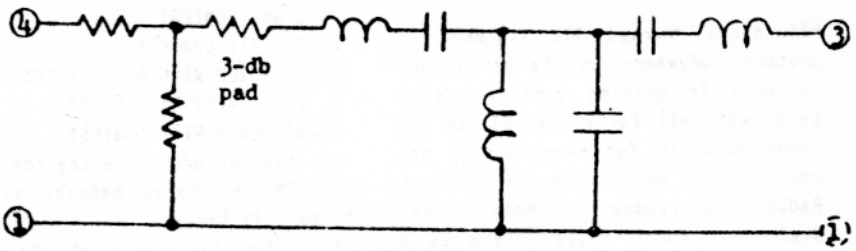
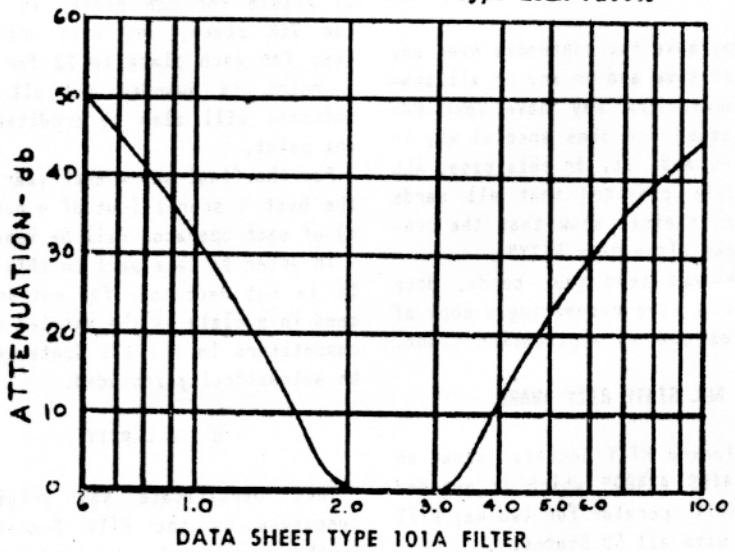


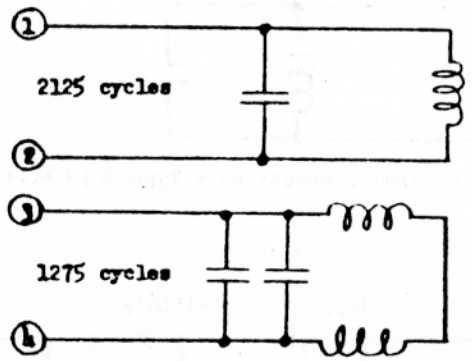
Input Terminals: 1 - 4
Input Impedance: 600 Ohms
Output Terminals: 1 - 3
Output Impedance: 600 Ohms

Total insertion loss = 4 db

Typical Characteristics - Type 101A Filter

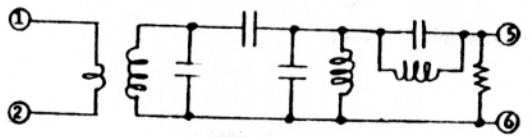


Internal connections Type 301D Filters



Internal connections - Type 301D Filter

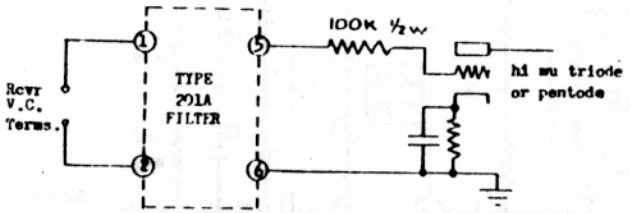
DATA SHEET TYPE 201A FILTER



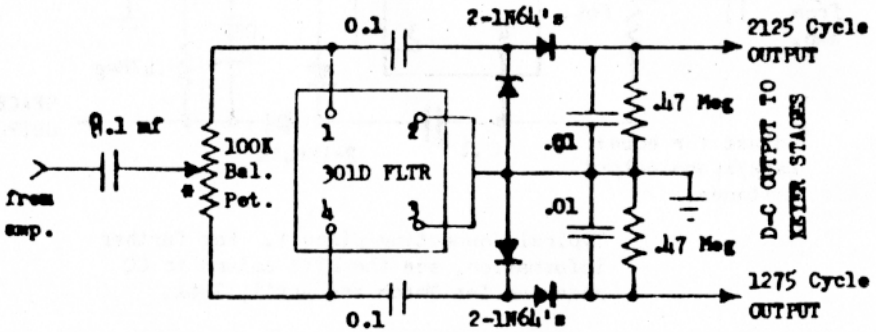
Internal Connections - Type 201A Filter

Input Terminals: 1 - 2
Input Impedance: 4 ohms (approx)

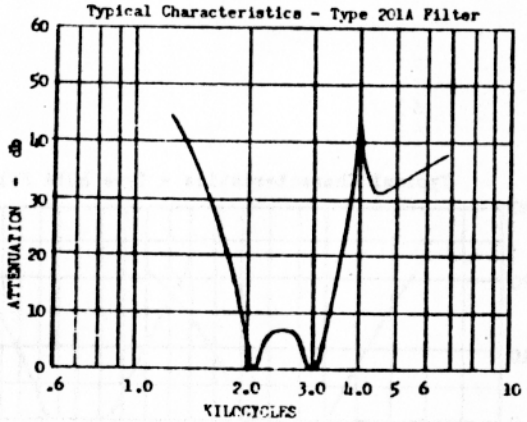
Output Terminals: 5 - 6
Output Impedance: 10,000 ohms (self-terminated)



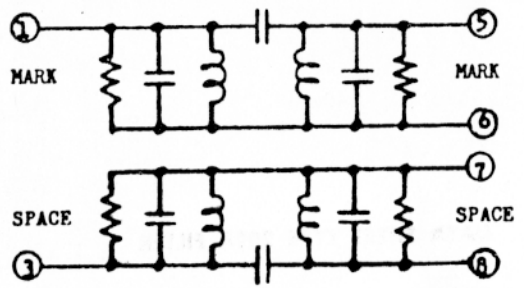
Typical Connecting Circuit - Type 201A Filter



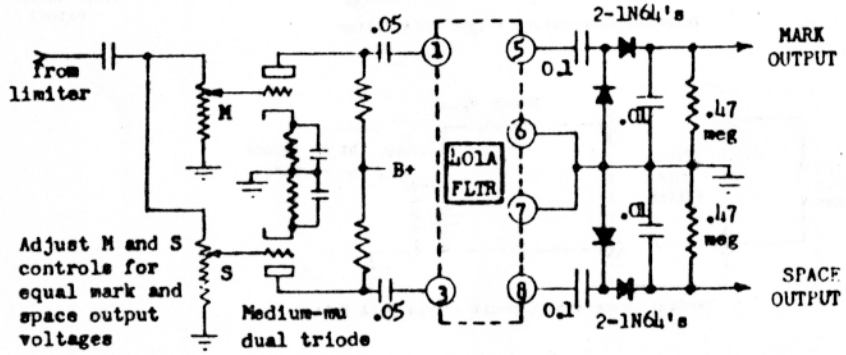
Typical Connecting Circuit. For further information, see the RTTY column in CQ magazine for March and April, 1961



DATA SHEET TYPE 401A FILTER

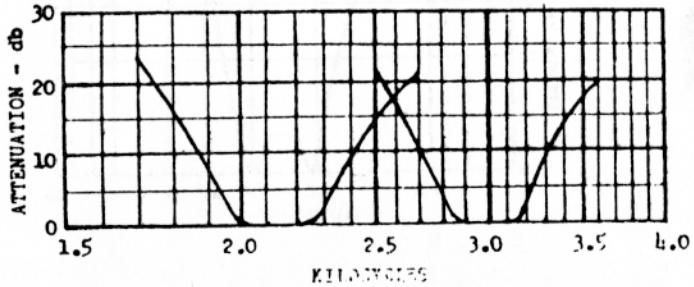


Internal Connections - Type 401A Filter

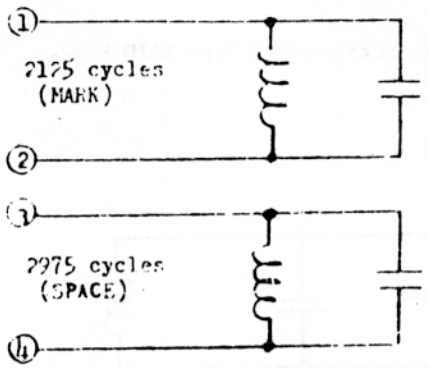


Typical Connecting Circuit - Type 401A Filter

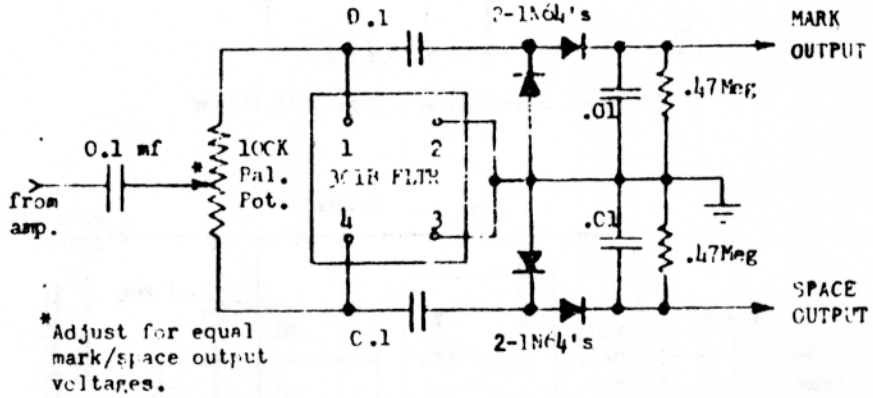
Typical Characteristics - Type 401A Filter



DATA SHEET TYPE 301A FILTER



Internal Connections - Type 301B Filter



*Adjust for equal mark/space output voltages.

Typical Connecting Circuit. For further information, see the RTTY column in CQ magazine for March and April, 1961.

RTTY MICROCOMPUTING

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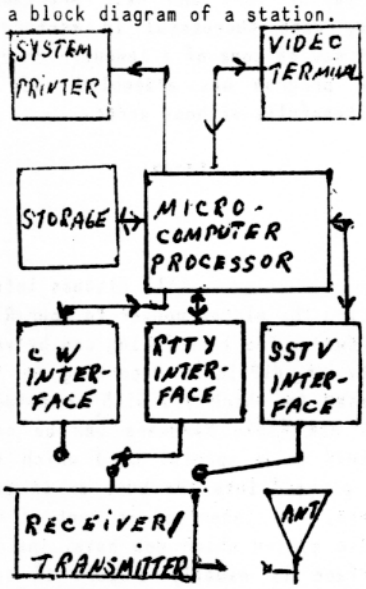
A micro-computer in a Ham radio application is a box which allows the reception, transmission and logging of amateur radio contacts. They are very general purpose in their design, and by the use of a program can be customized to perform a specific task. In some cases they can replace certain pieces of equipment around the shack. In other cases they supplement older equipment.

Let's look at how a well equipped station might apply a general purpose micro-computer system. The following is a block diagram of a station.



Let's examine how one might use such a system. The terminal in all cases is used to communicate to and from the amateur equipment to the micro-computer. By typing the appropriate command into the terminal, the CW, RTTY, or SSTV program is loaded from storage into the micro-computer. The terminal is now the means by which you can communicate with the receiver and transmitter. The computer is now under control of the program.

The terminal, in most cases, is a self contained ASCII video unit or just a simple ASCII keyboard plugged into a video electronics display.

The printer is usually the most expensive portion of the system and is used to print hard copies of amateur radio contacts or listings of computer programs. A non Ham friend of mine recently purchased a Model 15 printer to list his computer programs. An equivalent modem vintage printer can cost more than $500.

The interface boxes shown in the above diagram are just audio demodulators on the receive end. On transmission, the RTTY and SSTV interfaces are audio tones and the CW is a relay closure plugged into the key jack of the transmitter.

I've just described how a micro-computer might be used in an Amateur Radio application. As you can see, they don't necessarily replace equipment but supplement it. I found that my station was becoming a clutter of boxes for various types of amateur radio communications techniques.

Micro-computers allow you to combine functions in a single box and change the boxes function quickly by loading from storage a new program thereby changing the boxes function. For example, I can switch from RTTY to SSTV in a manner of seconds by loading a new program off my disk drive and throwing one switch.

*****

Obtaining a home computer is like buying any expensive home appliance. The best way to learn about them is to read articles, books, and talk with others. Computer Clubs are active throughout the world, attend some meetings and ask questions.Don't forget home computing can be quite expensive. Research the subject well, and don't jump too fast, you may be sorry later.

Let's explore, in a general manner, the types of home computers currently available. They primarily fall into three groups:

1. Single Board Computers with limited expansion capability.

2. Packaged Systems with a bus structure and good expansion capabilities.

3. Home Brew Systems with a bus structure and unlimited expansion capabilities.

A few samples of each type of system are:

1. Single Board Systems-Pet, TRS-80, Apple, etc.

2. Packaged Bus Systems-OSI, North Star, SWTP, Midwest Scientific.

3. Home Brew Systems-S100 or SS50 bus cards purchased from one of hundreds of manufactures.

You may have noted that I stressed the word expansion in all my descriptions. Expansion means that you can add hardware features to your system to do new and different things like play music, memory or even allow the system to speak. You will find that home computers always grow in size. (Murphy's law).

I also threw out another term called a bus. A bus is nothing more than a number of connectors mounted on a printed circuit board with all equivalent pins connected together. Each pin on the connector has a name and a defination for the signal applied to that pin. The most popular home computer busses are IEEE S 100 (100 pins) and the SS50 (50 Pins).

Cards can be plugged into the bus to serve various functions. Let's explore some of the advantages and disadvantages of each system as follows:

1. Single Board Computers.
Reasonable initial cost.
Expansion limited and costly.
Software easy to obtain on some systems.
Not suitable for all ham radio applications.
Poor and limited documentation.
RF & TVI prevalent on some systems.
Can be obsolete easily with technology advances.

2. Packaged Bus Systems (assembled or kits).
Higher initial cost.
Expandable due to bus structure of system.
Software available from manufacturer and other sources.
Suitable for all ham applications.
Good documentation.
Easy to modify and expand.
Can be upgraded as technology advances.

3. Home Brew Bus Systems.
Lowest initial cost.
Can be expanded at low cost.
Wide distribution of software in clubs.
Best way to go for ham applications.
Never obsolete, can expand as technology advances.

Sometimes difficult to get operational.

Once you have selected a possible system, the availability of software should be investigated since this topic requires considerable discussion.

*****

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Since most of you are interested in developing a system for amateur radio applications, I'll stress this subject the most. You may have noted in most ads for software a number of buzz words describing various types of software for home computers are used. Most of these ads are for high level software like Basic, etc. This type of software is excellent for most home applications like games and other household chores. However, in amateur radio applications, this type of high level programming is not sufficient. Most amateur radio applications are logic replacement, which means you are replacing software for hardware. Therefore, you require that the software be as efficient as possible. This means that high level languages are not satisfactory for most ham applications. More on the subject later.

You may ask what is a high level language? Well, it is similar to English, in that you can write a statement to perform a task directly. This statement is converted to machine language that the processor will understand by the high language interpreter. For a single high language instruction, the interpreter might issue 20 instructions to the processor. For example, a typical high language statement in Basic is "PRINT". The interpreter will convert this word to a form that the machine will understand and print a message on the screen.

A machine language instruction is an instruction which the particular type of processor understands. This is the only type of instruction which will cause the processor to do something. Each processor type has its own machine language and code, for one processor will not run on another except in certain cases, i.e.

8080 code will run on a Z-80 processor.

Z-80 code will not run on an 8080 processor.

6800 code will not run on a Z-80 processor etc.

Therefore, you can see that your choice of processor should not be made only on the cost and hardware availability. If you don't want to write your own software, investigate what is available for the processor you are considering.

I discussed earlier that high level languages are not suitable for amateur radio application. This is due to speed. Most amateur radio applications require a completely devoted processor. High level languages add an enormous amount of time to convert the English type instruction to machine language.RTTY and CW are somewhat tolerant to slow software due to their slow rates, however, with SSTV applications, every microsecond of time is important.

Well, you might ask how do I generate microprocessor code for ham radio? This is accomplished by two machine language programs called: TEXT EDITORS and ASSEMBLER. The following is a brief description of each of these items.

1. Text Editors are used to enter assemble language code into the memory of the processor. Text Editors are an excellent means of entering any form of text. They allow you to edit or change the text or find a portion of the text which you wish to change. Text Editors can also be used to create an amateur log book which can be stored away and recalled at any time from storage in the microprocessor.

2. Assemblers take the text file and convert the file to machine language. The machine language can be stored and recalled at any time.

Assembly language is a pseudo English like statement, which allows you to write machine language statements easily. In Assembly language, you do not have to remember as much as required in machine language programming.

Assembly language is not difficult to learn. You will find many books and courses offered at your local college and night schools. I would like to encourage you to try machine language programming. You can get a lot of satisfaction using your own program over the air.

With the FCC giving permission for ASCII to be transmitted over the air, I'm sure more processors will be used for amateur radio contests. The generation of ASCII RTTY programs will be very easy for any processor.

I understand from VK3UM that he and VK4XV have been exchanging software programs on 20 meters with good success at 110 Baud ASCII. Their software consisted of a text editor and a serial port on their processor. They were successful in exchanging the source code of a computer program. The program was assembled and ran successfully without error.

*****

I'll discuss interfacing the microcomputer to your RTTY hardware. The interfacing can be very easy or difficult depending on the system to which you wish to attach. The Ham Radio hardware can be contained on a special card which can be plugged into the bus, or in many cases, the interface is part of the basic system which you have. The interface is usually a port of some type. This port can be serial or parallel. The parallel ports are the most flexible and can be interfaced quite easily. Most serial ports are designed for ASCII use and have too many data bits for Baudot code reception and transmission. So I will not talk much about these devices. Let us explore how parallel ports can be best utilized.

You may ask, "What is a port?" Well a port is nothing more than a path from the microcomputer to the outside world. Typically, a port has 8 data bits or more on a single integrated circuit. Each bit can be visualized as a single wire which can be turned on or off under program control. Sound easy? Well it is! If you want

DRAKE® Theta 7000E Microprocessor-Controlled Communications Terminal

New versatility for the old bear in your station . . .

The perfect addition to any amateur radio installation! Complete, automatic send/receive of Morse code (cw) Baudot code (RTTY) and ASCII code (RTTY). Works with any video monitor.

Model 7000 **Drake Theta 7000E Terminal**
Model 7009 **Drake TR-930 Video Monitor**

7-Channel Battery Back-Up Memory, the Theta 7000E has seven keyboard-selectable, non-volatile, random access memory channels each of which can hold 64 characters. Data in these memories is alterable at any time and is retained when power is removed. Messages in these memory channels can be repeated 1 to 9 times via keyboard command. All channels may be daisy-chained for continuous read-out. Channel number in use is indicated on display.

Wide Range of Transmitting and Receiving Speeds, 5 to 50 wpm in Cw with autotrack on receive. Standard RTTY speeds of 60, 67, 75, and 100 wpm Baudot code and 110, 150, 200, and 300 Baud ASCII code.

Self Contained Demodulator, three-step shift selects either 170 Hz, 425 Hz or 850 Hz shift with manual fine tune control of space channel for odd shifts. High/low tone pair select. Mark only or space only copy capability for selective fading.

CONVENIENT KEYBOARD FEATURES, automatic keyboard-operated transmit, (KOX) or manual keyboard transmit. **Unshift on space,** reverts to LETTERS case after reception of each space character in Baudot code. **CR/LF is automatically inserted** every 60, 72 or 80 characters while transmitting. **Cw identification,** in RTTY mode. **Echo function,** prerecorded cassette tapes can be read and transmitted. **Test messages,** "RY" and "QBF". **Transmit word mode,** characters can be transmitted in word groupings.

Crystal Controlled AFSK Modulator:

High Tone Pairs	Shift	170 Hz	425 Hz	850 Hz
	Mark	2125	2125	2125
	Space	2295	2550	2975
Low Tone Pairs	Shift	170 Hz	425 Hz	850 Hz
	Mark	1275	1275	1275
	Space	1445	1700	2125

• **Printer Interface for Hard Copy,** all modes for parallel ASCII printers. Loop keyer for conventional teleprinters. • **Composite Video Output,** for any standard video monitor. • **Kansas City Standard AFSK Output,** KCS tone pair for ASCII. • **Large Capacity Display Memory,** two page display memory contains 32 X 16 lines per page. • **Split-Screen,** with a keyboard command, the display can be divided in two; the upper half for transmit and the lower half for receive. Messages can be composed while receiving. • **Buffer Memory,** 53 character type-ahead keyboard buffer. • **Word Wrap-Around,** in receive mode, word wrap-around prevents the last word on a line from becoming split in two. Moves whole word to next line. • **Automatic Letters Code Insertion,** if desired, LETTERS (diddle) code can be transmitted continuously in a pause of transmitting from the keyboard. • **Audio Monitor,** a built-in audio monitor circuit with automatic transmit/receive switching enables checking of the transmit/receive tones. • **Transmitter Keying Circuitry,** keys either grid block, cathode keyed, or solid-state transmitters. • **Power Requirement,** The Theta 7000E requires only 13.6 Vdc @ 1 amp. Plugs into 13.6 Vdc accessory jack on PS7 or PS75 power supplies. • **Effective Packaging for RFI Protection,** well designed metal cabinet and protective circuits prevent RFI. • **Terminal Size:** 15.8″W x 11.8″D x 4.7″H (40 x 30 x 12 cm) • **Weight:** 11 lbs (5 kg) • **Monitor Size:** 8.7″W x 9.8″D x 8.9″H (22.1 x 24.1 x 22.6 cm) • **Weight:** 11 lbs (5 kg)

Model 1230 LA7 Line Amplifier

Line output, input levels as low as 15 mV rms (47 kilohm) will result in an output of 1 mW nominal into a 600 ohm balanced line. Output level adjustable by internal pre-set level control. Interfaces low level audio to RTTY terminal unit or phone line that requires a 600 ohm balanced/unbalanced input. One 36" phono to phono cable supplied. • **Size:** 4.5″L x 1.3″H x 2.5″W (11.4 x 3.3 x 6.4 cm). **Weight:** .3 lbs. (.14 kg).

Specifications, availability and prices subject to change without notice or obligation.

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1D-07k/LA-681

to turn on one of these port bits, all that has to be done is to program the bit as a one or a zero. Likewise, if you want to read the status of the bit to see if a signal is present, all that has to be done by the computer is to read the port. You can now test if the bit is on or off by a special instruction. By the way, a "one" in computer jargon is a positive voltage (approximately 5 volts) and a "zero" is ground. Well this all sounds quite simple, so let's confuse the issue by bringing up another factor called time. Time is another dimension which you can handle by two methods.

You can attach some external hardware to the port to control the timing or you can let software handle the timing. This is entirely up to the person designing the system. If your specialty is not programming, then hardware can do the trick. If you enjoy programming, you may wish to use this method. As you know, in order to transmit RTTY at 60 WPM, a data rate of 22 msec and a stop bit time of 31 msec duration must be used. These timings can be generated in one of two ways:

1. HARDWARE METHOD

The hardware technique is to attach a universal asynchronous receiver/transmitter (UART) to a micro parallel port. This device is typically an integrated circuit with 40 pins. An excellent device for this application is a 1602 UART which is available from a number of sources for around $5.00. This device can receive or transmit data with 5 to 8 bits, at whatever data rate applied to the chip. This data rate is controlled by an oscillator on the interface circuitry. To change speeds, the frequency of this oscillator must be changed. The output of this device is a positive or zero level TTL level. Therefore, to use this for RTTY, a modulator and demodulator (T.U.) must be connected to the UART.

2. SOFTWARE METHOD

The software methods are a little more abstract, however, they accomplish the same effect. However, they have two big advantages:

A. The software technique uses less hardware and the only cost is the expense of software development.

B. Any data pattern (ASCII or BAUDOT) and speed can be generated with slight program changes.

The software timing technique is simple to explain. All you have to do is turn on a bit port. Place a delay in the program by counting down a counter until it is zero. You can then turn the bit on the port off. The duration of the delay will be the period of the signal. To change the frequency of the signal, all you have to do is change the initial value loaded in the counter.

So far I have only discussed the transmission of RTTY, reception is the exact opposite. All you have to do is reverse the process. To do this you first look to see if a signal is present. If it is, you delay a data bit and one half. Then look for an on condition, if so you have received a data bit. You can then repeat the entire process until an entire five bits or a Baudot character has been received.

In all of my RTTY microcomputer applications, I have used the software technique for transmission and reception. I have written about 10 different software packages for the 6800 and 6809 microcomputers. Just last week (11-30-80), I received my new TRS color computer which uses a 6809 microprocessor. I believe this is an excellent low cost ($399) computer for Amateur Radio applications. Interfacing is very simple due to the built in RS232 port. I was very pleased to find the color computer, unlike other Radio Shack products, very clean with no TVI or RF interference. Even with the computer a few inches away from my TV set. It will be a lot of fun developing RTTY and SSTV software packages for this machine. Imagine looking at RTTY in full color on your TV.

*****

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San Diego, CA 92124

Having been a computer programmer for sixteen years and an avid RTTY operator for five years, I was asked by the RTTY JOURNAL to do a users report on the new Super RTTY System by Q.C. Systems. After using this system for a month, tearing it apart and putting it back together,I can highly recommend it as an economical, solid RTTY operating system.

The Super RTTY program is a full disk I/O system designed specifically to operate on Heathkit H-89 and H8 micro processors. Both ASCII and Baudot codes are supported along with automatic CW ID if selected.

The system is supplied on two disks, one containing the object code and system documentation, and the other containing the source codes. Access to the source is one of the outstanding features of this system over other commercially available systems.

A very unique feature of this program is the use of a Default file on the operating disk for setting at your desired operating perameters, including setting the data for any of the three line buffers. These perameters may also be changed at any time you are in the Receive Command mode.

The program creates one disk file that can be used as the station RTTY log for a month at a time. This file contains all the information about System Start up/Shutdown, transmitter on/off time and station operator, along with any notes the operator wishes to include.

If the operator desires, all received data can be saved on another disk file.

There are provisions in the program for transmitting <u>any</u> file on the operating disk.

There are provisions in the program for line printer or alternate terminal on line hard copy of both Received and Transmitted data.

Super RTTY's Screen display is also unique. The display is three leveled, with an adjustable split line separating Received data and Command/Type ahead data. The outgoing

data is displayed in Reverse Video Marquee fashion on the 25th line. This line is cleared while in the Receive/Command mode.

Received data is displayed on the line above the split line and scrolls up and off the screen. Commands and type ahead transmit data are displayed on the 24th line and scroll up to the split line.

The split line displays present real time in hours and minutes.

Commands used with the system are straight forward shorthand notations of the function to be performed.

As there are many different commands for the program, a prompt card made from the last two pages of documentation are extremely useful until the operator gets used to the system.

The more one uses this system on the air, the more you like its many and varied features.

Two things this operator disliked were the need to close the type ahead buffer prior to entering the transmit mode and the extreme slowness of the CW ID.

The program is very well written, in a sophisticated modular concept.

To fledgling programmers, the best part of this system are the price and inclusion of the Source listing. If you don't like a feature of this system, you can change it.

I have just finished a "contest" addition to this operating system which will give universal contest line selection, automatic contest message generation (with message number up-date) and automatic Band/Call sign duplicate checking upon entry of a call sign. Provisions were included for logging of Received and Transmitted contest information and the split line was expanded to include date, RST to be sent, current message number, and the callsign of the station being worked, all in reverse video for highlighting.

For economical price, this is a RTTY operating system no Heath user can afford to not have in his library.

*****

PREVENTING RFI TO AND FROM A MICROPROCESSOR

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San Diego, CA 92124

Transmitters, receivers, and microprocessors often do not mix well, due to RFI. The enclosure is a major factor effecting the RFI level, both to and from a microprocessor.

A metal enclosure is the best solution, but due to the size and shape of some microprocessors, the cost is prohibitive. For example, the Heathkit H89 which includes a built-in CRT, is quite large.

The next best solution is application of a conductive coating to the inside of your plastic enclosure. There have recently been developed several different conductive coating paints, using a variety of metals, from gold, to nickle as the conductive pigment. A nickle pigment paint is the most economical paint and works quite nicely.

The product I have found is called XECOTE (trademark) and was developed by the Metex Electronics Shielding Group. Due to the nature of this paint, great care must be taken in handling it, and good quality spray paint equipment must be used for its' application. This paint is quick drying and will air cure in approximately 24 hours. One gallon will cover 270 square feet of surface with a coating of .002 to .003 inch thickness.

This thickness will give approximately 60 DB of shielding, with a one ohm per square resistance. It has been applied successfully to a variety of plastics without the use of a primer. (Acrylics, plexiglas, lucite, polycorfornate, etc.).

Using one pint (cost approximately $35.00), I sprayed a Heathkit H89, H19, and H8. No RFI problems from or to the above equipment has been detected since the coating was applied.

Possible sources of this product are: Metex Corporation, 970 New Durham Road, Edison NJ 08817, Tel: 201-287-0800. Or: Cal-Metex, 20437 S. Western Ave., Torrence, CA 90501, Tel: 212-320-8910. XECOTE is a registered trademark of the Metex Corp.

NATS' GLOSSARY OF RTTY

AFSK-Something which is illegal on HF bands but Okay to do.
Air Core- now known as Air Force.
AMP-bug with six legs.
Arrestor-Officer of the law.
Autostart-rotation of the ignition key.
Banana plug-used on leaky bananas.
Buffer-substitute for asprin.
Buss- used for transporting amps.
Capacitor-one who can hold their liquor.
Centimeter-long critter with many legs.
Chad-see Chadless
Chadless-see Chad
Choke-What your spouse does to you when seeing your new rig.
Decivel-used to warn ships.
Detector-someone who works for the FBI.
Discriminator-a member of the KKK.
Discriminator-one who insists upon washing white clothes by themselves.
Diode-something we all hope to do.
Dummy load-a guy who carries his mother-in-law around.
Exciter- Rachel Welch
Farad-Egyptian ruler.
Feed thru-a slot in a jail cell.
Final output-taking the garbage out for the last time.
Flat topped-it's hard to get excited about this .
Flux-a four letter word.
Flyback-return on an airplane.
Front end-(good example) Dolly Parton
Gamma match-a new game show.
Ground-loop race car track.
Ground fault-area known for earthquakes.
Henry-Jane Fondas' dad.
Hertz-when someone steps on your toes
Kayboard-a bored key.

MODEL 28 SPEED CONVERSION- When converting a model 28 3 speed gearshift from 60-67-100 to 60-75-100 WPM, it is necessary to change gears #195263, 22 teeth and 195264 49 teeth to #145-369 24 teeth and #145374 47 teeth. W9CPD.

TYPEBOX CLEANER- A good ole toothbrush and soapy water removes ink buildup from hard to get to places on 28 series printer typeboxes. Be sure to oil properly to prevent rust buildup on hammers and springs.

SPEEDS (Baudot Code)

Speed Name	Actual WPM	Bauds	Operations Per Min.	Select Pulse-MS	Stop Pulse-MS	Shaft Speed-RPM
60	61.35	45.45	368.1	22.	31.	420.
75	76.67	56.88	460.	17.57	25.	525.7
100	100.00	74.20	600.	13.47	19.47	685.
Western Union	65.00	45.45	390.	22.	22.	420.
Std International	66.67	50.00	400.	20.	30.	461.5

$$\text{Operations Per Minute} = \frac{60}{\text{Seconds per character}} = \frac{60}{.163} = \frac{368,1 \text{ OPM}}{60 \text{ Speed}}$$

Words Per Minute = OPM/6 = 368.1/6 = 61.35 WPM at 60 Speed

$$\text{Bauds} = \frac{1}{\text{Speed of one information bit}} = \frac{1}{.022 \text{ MS}} = \frac{45.45 \text{ Baud}}{60 \text{ Speed}}$$

Std bit interval = 22 MS (.022 sec)

Character interval = Seconds per character/.022 $\frac{.163}{.022} = \frac{7.41}{}$

If speed in bauds (one pulse/second is one baud) is equal and shafts turn at same rpm, codes are compatible.

There are seven units of code for Baudot code. The units are:

1st - Start (space)
2nd-6th - Information Code (mark or space)
7th - Stop (mark)

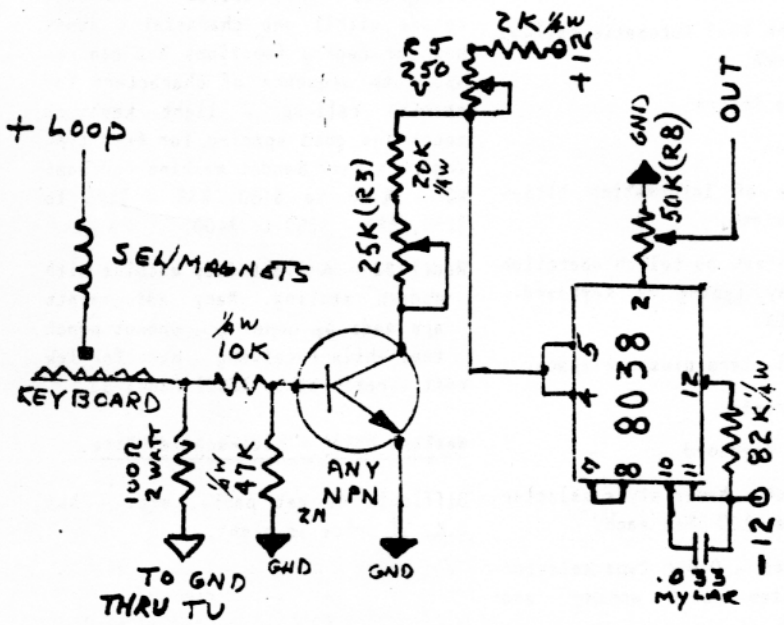
HAM HELPS

TAPESPLICE-I find that any given surface such as the glued part of an envelope or brown craftpaper cut to 11/16" and run through the perf with an all "ltrs" combination, makes an excellent splice tape for torn sprocket hole tapes....K9WRL.

PAPER HANDLING-Heavy model 19 & 28 series printers can be greatly aided in movement by a set of dolly casters found at your local hardware stores. A blessing on carpeted surfaces.W7GPP

*** page 21 column 2.** (NOTE: an inverting circuit should be placed between the keyboard and the circuit in figure 1. to give normal space high mark low operation.)

****page 37A-** schematic for this article is below.



SOME SOURCES FOR SUPPLIES

The following (non-alphabetical) list are sources for RTTY supplies. For prices etc. send SASE to source for a reply.

Atlantic Surplus Sales, 3730 Nautilus, Brooklyn, NY 11224. Printers, TD's, parts and other TTY items.

HAL Communications, Box 365RJ, Urbana, IL 61801. PC boards, kits, video printouts and keyboards, complete systems and the new RTTY/CW Portable reader.

Info-Tech c/o Digital Electronic Systems, Inc., 1633 Wisteria Court, Englewood, FL 33533. Communications terminals, expansion boards.

R.L. Drake Co., 540 Richard St., Miamisburg, OH 45342. Microprocessor-controlled Terminals.

irl, 700 Taylor Rd., Columbus, OH 43230. Terminal units.

Dialta Amateur Radio Supply, 212-48th St., Rapid City, SD 57701.

Dovetron, 627 Fremont Ave., S. Pasadena, CA 91030. Complete transmit-receive modems, TSR's etc.

Daytapro Electronics, 3029 N. Wilshire Ln, Arlington, IL 60004. RTTY Kits and PC boards.

Universal Electronics, 1280 Aida Dr, Reynoldsburg, OH 43068. Worldwide RTTY Frequencies.

R. Wilson, WBOESF, 4011 Clearview Dr, Cedar Falls, IA 50613. Back issues of the RTTY JOURNAL reprinted

RTTY-TERMS

RTTY - Radio Teletype

Auto Start - Electronic circuit to turn on machine motor and loop when message is being received. Usually responds to the mark tone frequency.

Mark - Similar to CW key down or closed.

Mark Tone - 2125 Hz tone at receiver audio output.

Space - Similar to CW key up or down.

Space Tone - 2295 Hz (narrow shift) or 2975 (wide shift) tone at receiver audio output.

Narrow Shift - 170 Hz shift between mark and space tone.

Wide Shift - 850 Hz shift between mark and space tone--this shift is not used on the low frequency bands and is rapidly becoming obsolete--max shift permitted by FCC is 900 Hz.

Bias Distortion - Mark signals not equal standard time duration. Longer= marking bias, Shorter = spacing bias.

Range Finder - Part of printer to adjust for distortion--the range is in percent of a code unit--a range of 10 to 90 is perfect--low end is spacing bias--high end is marking bias--range is graduated in 0-120 points.

Baudot - A code system using five information bits plus a start and stop pulse--there are 32 possible different combinations of the five bits (25 = 32).

ASCII - A code system based on eight information bits.

FSK - Frequency Shift Keying--Shifting the RF carrier frequency for desired shift--F1.

AFSK - Audio Frequency Shift Keying--Shifting the audio tones into the transmitter for desired shift--A2.

TD - Transmitter-Distributor--To transmit punched tape.

Reperforator - To punch tape, may be printing or non-printing and chadless or fully perforated--sample is chadless as chads are attached to tape.

KSR - Keyboard-Send-Receive (no tape equipment).

RTTY-TERMS

ASR - Automatic-Send-Receive (with reperforator and TD).

RO - Receive Only (page printer only--no keyboard).

Loop - The electrical circuit from the TU power supply through the machine--a closed loop is a mark, an open loop is a space 120 volt DC--usually 60 MA for parallel selector magnets.

Running Open - Loop in open or space condition--machine runs eratic since stop signal is not present.

Mark Hold - Electrical feature of TU to provide stop signal to prevent machine from running open on prolonged space tone.

TU - An electronic circuit or "converter" to pulse the loop for mark or space signals--also usually provides a FSK signal of low voltage (+ or -15 VDC) to FSK the VFO or signal the AFSK oscillator for transmitting RTTY.

Stunt Box - A mechanical device to provide machine functions and decode sequential call up codes--will control printing, CR, LF, bell, spacing, non-overline, WRU, and will operate electrical switches. Can provide memory of command.

WRU - Who Are You? Automatic call-up and answer back.

CR - Carriage Return

LF - Line Feed

Baud - Rate of information bits--pulses per second.

KOX - Fast break no switch operation controlled by typing on keyboard--similar to VOX.

Word - Five letters plus one space.

Red Jack - Printer

Black Jack - Keyboard

Holding Magnet - Newer style selector magnet system--100 ohms each.

Pulling Magnet - Older type selector magnet system--uses spring and adjusting nut.

MACHINES (BAUDOT)

Teletype

Model 12 - 1920 era obsolete but usable.

Model 14 - Reperforator - similar to Model 15 but tape punch - look for longer stop segment - $15 to $40.

Model 15 - A good rugged page printer capable of up to 75 speed. Somewhat noisy - has limited functions (no stunt box) - slow carriage return - type bars and basket - keyboard somewhat stiff and keys widely spaced - a good starter machine - price range $45 to $75.

Model 19 - A Model 15 page printer with perforator and Model 14 transmitter-distributor (TD) mounted on a steel table with wiring enclosed behind the table. $50 to $100 price range.

Model 26 - Page printer fixed at 60 speed. Uses type wheel - not a popular machine but a try at design improvement over the Model 15.

Model 28 - The best Baudot machine by Teletype. Being phased out by many for Model 35 which is the ASII version. Will run at 60, 75, or 100 speed - uses type box with changeable type pallets - carriage return within one character - stunt box for coding functions and can respond to sequence of characters for station call-up - light keyboard touch and good spacing for fast typing. The best Baudot machine for hams RO - $100 to $150, KSR - $175 to $250, ASR - $250 to $400.

Model 32 - A light duty machine with modern styling. Many adjustments are made by bending - cannot punch tape while receiving - made for low cost - replaced by ASCII Model 33.

Western Union - Kleinschmidt-Mite

Difficult to get parts, etc. - but O.K. if price is right.

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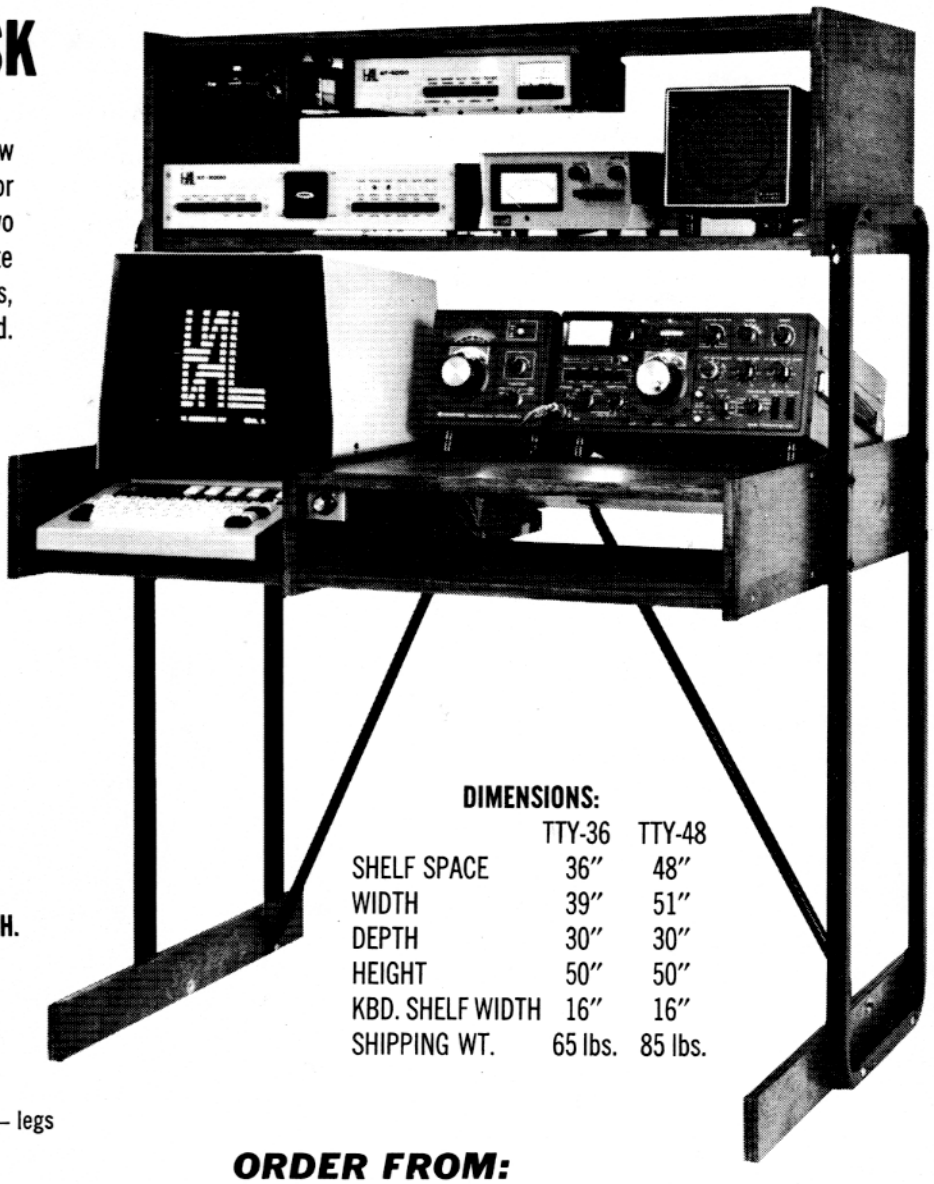

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